DEPARTMENT OF THE ARMY

TECHNICAL BULLETIN

TOWED WHEELED VEHICLES, FSC CLASS 2330, LUNETTE TRAILERS AND SEMITRAILERS:

REPAIR OF FRAMES

Approved for Public Release; Distribution is Unlimited

HEADQUARTERS, DEPARTMENT OF THE ARMY
NOVEMBER 1995

Technical Bulletin
No. 9-2510-242-40

HEADQUARTERS
DEPARTMENT OF THE ARMY 15 November 1995

DEPARTMENT OF THE ARMY TECHNICAL BULLETIN

TOWED WHEELED VEHICLES, FSC CLASS 2330 LUNETTE TRAILERS AND SEMITRAILERS: REPAIR OF FRAMES

REPORTING OF ERRORS AND RECOMMENDING IMPROVEMENTS

You can help improve this bulletin. If you find any mistakes or if you know of a way to improve the procedures contained in the bulletin, please let us know. Mail your letter, DA Form 2028 (Recommended Changes to Publications and Blank Forms), or DA Form 2028-2, located in the back of this manual, direct to: Commander, ATTN: AMSTA-MM, Warren, MI 48397-5000. A reply will be furnished to you.

APPROVED FOR PUBLIC RELEASE; DISTRIBUTION IS UNLIMITED

TABLE OF CONTENTS

Section I. GENERAL 1
1-1. Purpose 1
1-2. Scope 1
a. Organizations 1
b. Lunette Trailers 1
c. SEMITRAILERS 1
d. Applicability 1
1-3. General Provisions 1
a. Maintenance Policy 1
b. Maintenance Levels 1
c. Repairs 1
d. Repair Techniques 1
e. Repair Capability 7
f. Overhaul 7
g. Improvement of Technical Bulletin 7
h. Warnings 7

Section II. FRAME MEMBERS, MATERIALS, AND ASSEMBLY 8
2-1 Frame Members 8
2-2 Frame Materials 8
2-3 Frame Assembly 8
2-4 Frame Galvanization 8

Section III. FRAME DAMAGE AND MAINTENANCE EXPENDITURE LIMITS 9
3-1 Frame Damage 9
a. Frame Deformation 9
b. Local Damage 9
c. Multiple Cracks 11
d. Corrosion 11
b. Local Damage 12
3-2 Maintenance Expenditure Limits 12
a. Maximum Permissible Repair Costs for Lunette Trailers 12
b. Maximum Permissible Repair Cost Procedures 12
c. Estimated Repair Costs 12
d. Technical Inspections 12

Section IV. FACILITIES, EQUIPMENT, TOOLS, AND SKILLS 12
4-1 General 12
4-2 Facilities 13
4-3 Tools and Equipment 13
4-4 Skills 13

Section V. FRAME STRUCTURE REPAIR PROCEDURES 13
5-1 Frame Members and Segments 13
a. General 13
b. Repair Planning 13
c. Damaged Frame Members 13
d. Welding Requirements 14
e. Bolts and Rivets 14
f. Buckled, Wrinkled, Mangled Segments 14
5-2 Frame Straightening 15
a. Temperature Conditions 15
b. Stresses/Stressing 15
c. Inspection 15
d. Application of Straightening Forces 15
5-3 Frame Welding 15
a. Remove Structural Load 15
b. Align Members 15
c. Prepare Weld Joints 15
d. Weld Joint 16
e. Strengthen Weld Joint 16
f. Treat/Paint Repair Joint 16
g. Cracked/Broken Weld Joint 16
h. Cracked/Broken Member 16
5-4 Repairing/Replacing Deformed Member 17
a. Complete Member Replacement 17
b. Segment Replacement 18
5-5 Repairing Deterioration Caused by Corrosion 18
a. Detection and Degree of Deterioration 18
b. Overall Corrosion Deterioration 19
c. Localized Corrosion Deterioration 19

Section VI. AXLE ALIGNMENT PROCEDURE 21
6-1 Perform Pre-alignment Activity 21
6-2 Normalize Suspension Loading 21
6-3 Position Trailer 21
6-4 Check and Adjust Lateral Position 21
a. Determine Lateral Position 21
b. Adjust Lateral Position 21
6-5 Check and Adjust Longitudinal Position 21
a. Axle No. 1. 21
b. Axle No. 2. 25
c. Axle No. 3 25
d. Bogie (Axles not Independently Adjustable) 25

APPENDIX A ..... LUNETTE TRAILER FRAMES AND MATERIALS
APPENDIX B ..... SEMITRAILER FRAMES AND MATERIALS
APPENDIX C ..... REINFORCEMENT DETAILS
APPENDIX D ..... DRAWING 12355846-400
APPENDIX E ..... WELD REPAIR FOR M747 TRAILER FRAME AND RAMPS
APPENDIX F ..... SAE J875 - TRAILER AXLE ALIGNMENT

LIST OF FIGURES

Figure 1. Common Lunette Trailer 2
Figure 2. Typical Flatbed Semitrailer. 3
Figure 3. Typical Lowbed Semitrailer 4
Figure 4. Typical Intermediate Flange Weld Joint Reinforcement 5
Figure 5. Typical Tank Semitrailer 6
Figure 6. Frame Deformation Diagrams 10
Figure 7. Lunette Trailer Axle Alignment 22
Figure 8. Semitrailer Axle Alignment (Separate Adjustment) 23
Figure 9. Semitrailer Axle Alignment (Bogie Adjustment) 24
Figure C-1. Corner Flange Weld Joint Reinforcement C-1
Figure C-2. Intermediate Flange Weld Joint Reinforcement C-2
Figure C-3. Corner Web Joint Reinforcement C-3
Figure C-4. Intermediate Web Joint Reinforcement C-4
Figure C-5. Web Weld Joint Reinforcement C-5
Figure C-6. Channel Member Reinforcement C-6
Figure C-7. Tube Member Reinforcement C-7
Figure C-8. Single Flange Reinforcement C-8
Figure C-9. Double Flange Reinforcement C-9

Section I. GENERAL

1-1. Purpose. This bulletin provides general information, technical data, and guidance to assist maintenance personnel in accomplishing various types of repairs on lunette trailer and semitrailer frames.

1-2. Scope. The contents of this bulletin apply to:

a. Organizations. All US Army organizations, installations, and activities, and the Reserve components worldwide.

b. Lunette Trailers. All U.S Army procured lunette trailers requiring frame repairs (either by in-house or contractor activities) specifically addressed by the content of this technical bulletin are listed in Appendix A. Figure 1 shows a common lunette trailer frame.

c. SEMITRAILERS. Common types of U.S. Army SEMITRAILERS are covered in this technical bulletin. Figures 2 thru 5 show common types of SEMITRAILERS. Appendix B lists SEMITRAILERS requiring frame repairs (either by in-house or contractor activities) specifically addressed by the content of this technical bulletin.

d. Applicability. This technical bulletin covers repair of lunette trailers and semitrailer frames and undercarriages only.

1-3. General Provisions

a. Maintenance Policy. Unless authorized by higher authority, repair of FSC Class 2330 towed wheeled vehicles (including lunette trailers and SEMITRAILERS) is limited to operations allocated to General Support (GS) and Direct Support (DS) or below, regardless of geographical location or custody. Lunette trailers shall not be delivered to a maintenance depot solely for the purpose of frame repair.

b. Maintenance Levels. Lunette trailer and Semitrailer repairs are allocated to the DS/GS maintenance level that could grant authority to supported units to perform the next higher level of repair if the supported unit has the capability and capacity to perform the repair.

c. Repairs. Restore unserviceable, economically repairable lunette trailer and semitrailer frames to a serviceable condition in support maintenance shops by repair or replacement of individual frame parts or components.

d. Repair Techniques. Frame repair techniques described in this bulletin are welding, riveting, removal of bolted members, replacement of bolted members, frame straightening, frame reinforcement, axle alignment, galvanizing repair, corrosion repair and painting. Ensure that reference material, such as technical data and publications applicable to these techniques, are readily available for the use of trained and certified personnel.

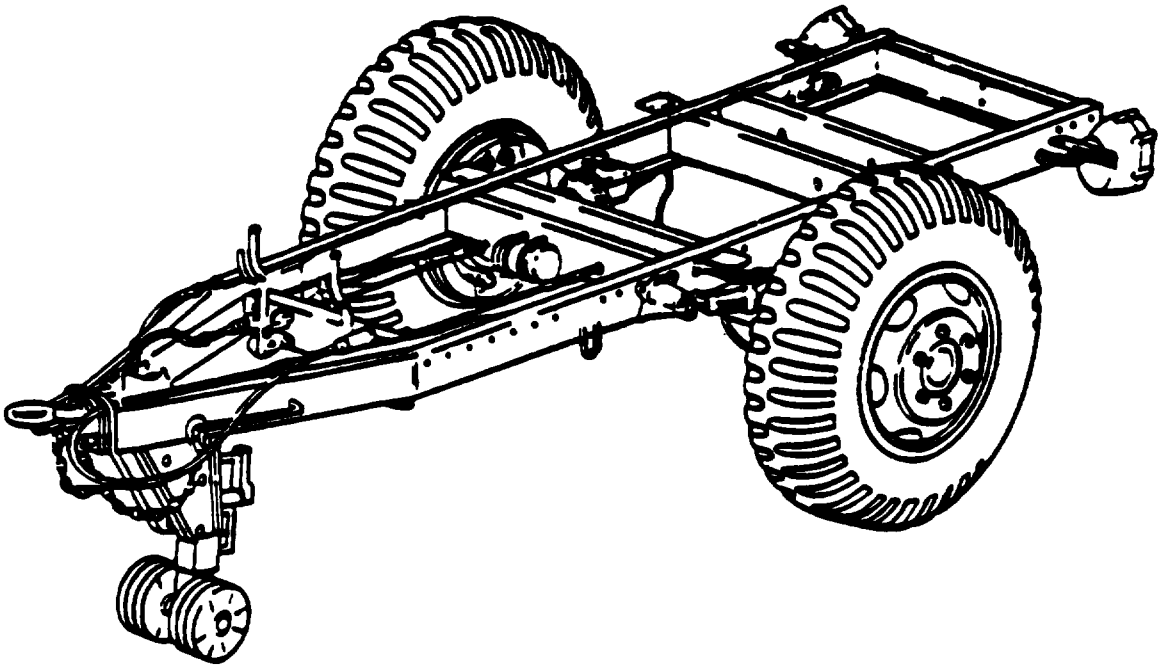


Figure 1. Common Lunette Trailer

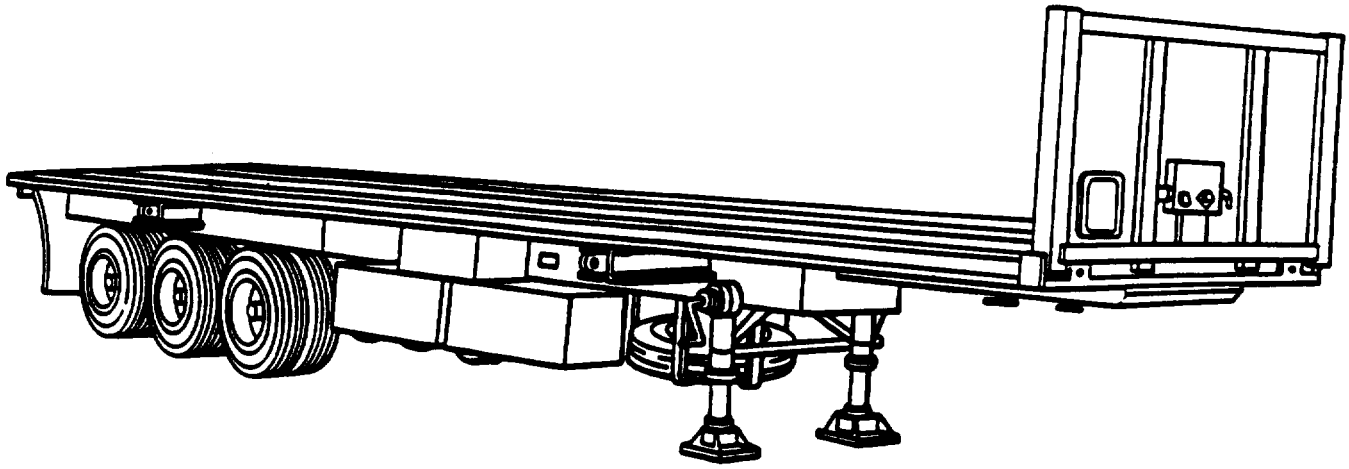


Figure 2. Typical Flatbed Semitrailer

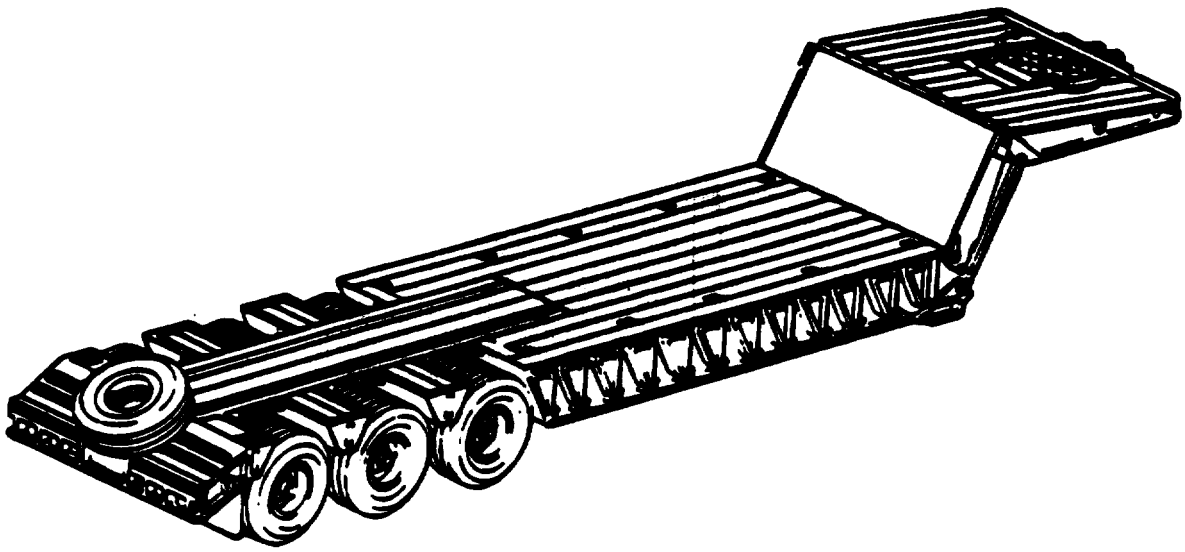


Figure 3. Typical Lowbed Semitrailer

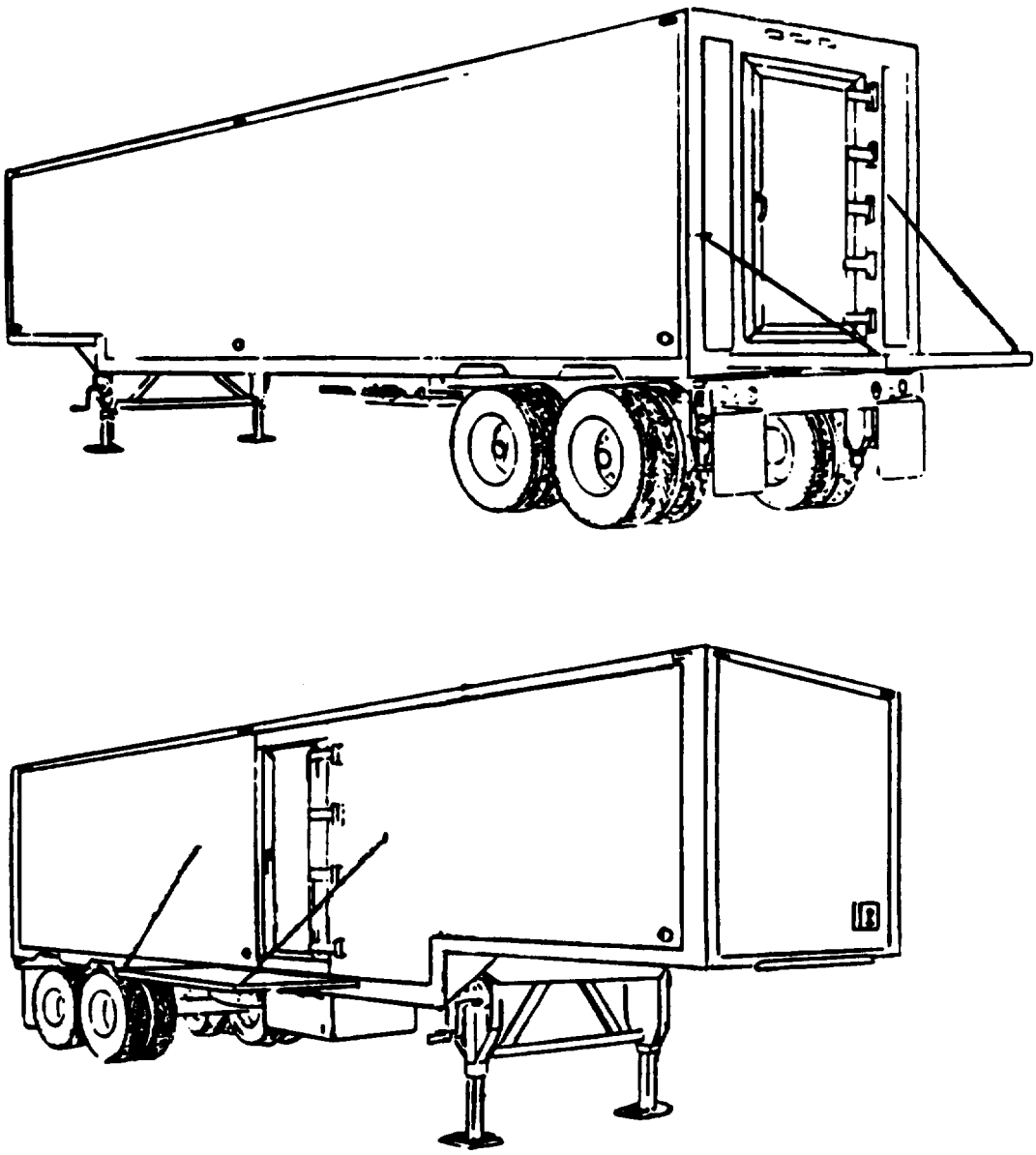


Figure 4. Typical Van Semitrailer

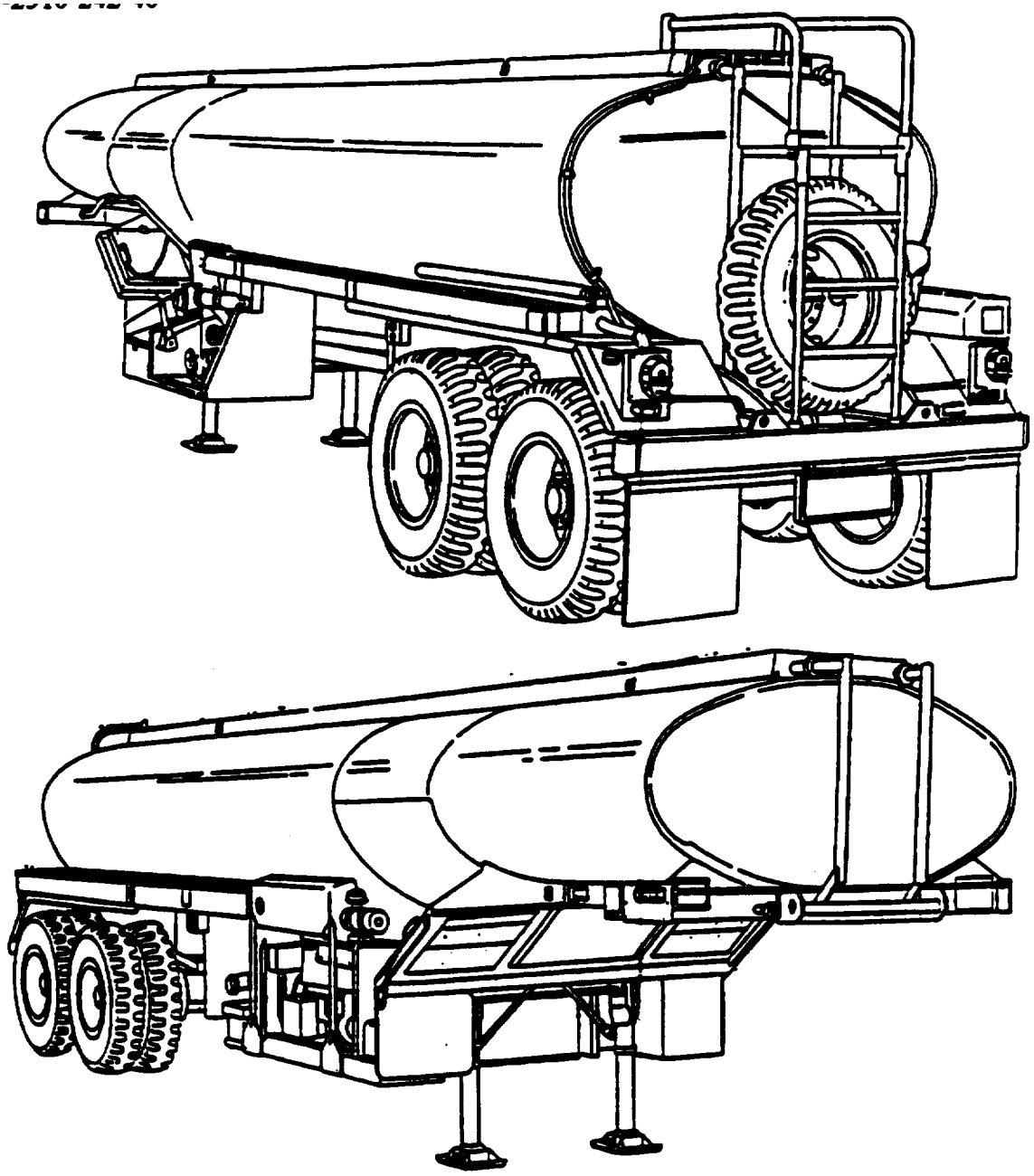


Figure 5. Typical Tank Semitrailer

e. Repair Capability. Repairs required to restore damaged lunette trailers and SEMITRAILERS to a serviceable condition vary with the type, degree, and location of damages. Complete and detailed frame repairs shall be at the discretion of the activities responsible for performing the repairs, since most of the work necessary to restore trailer frames and suspensions to a serviceable condition ultimately depends upon the skills and experiences of assigned maintenance personnel. All other repairs shall be performed in accordance with instructions in applicable technical manuals.

f. Overhaul. Depot overhaul, or limited depot overhaul of unserviceable lunette trailers and SEMITRAILERS shall not be accomplished below the depot level unless specifically authorized.

g. Improvement of Technical Bulletin. The reporting of errors, omissions, and recommendations for improving this technical bulletin is encouraged. Reports should be submitted on DA Form 2028 (Recommended Changes to Publications) and forwarded directly to Commanding General, U.S. Army Tank-Automotive Command, ATTN: AMSTA-MTT., Warren, MI 48937-5000.

h. Warning. Weld repair of fuel tank SEMITRAILERS requires precautions to prevent accidental ignition of fuel or fuel vapors remaining in pipes or the tank.

The following U.S. Army publications describe fuel tanker cleaning/purging:

1- FM 10-20 Organizational Maintenance of Military Petroleum Pipelines, tanks and related equipment.

2- FM 10-71 petroleum Tank Vehicle Operation.

3- TB 43-0212 Purging, Cleaning and coating Interior Ferrous and Terne Sheet Vehicle Fuel Tanks.

4- FM 10-69, Petroleum Supply Point Equipment and Operations

An appropriate respirator must be worn when grinding painted or galvanized surfaces.

Section II. FRAME MEMBERS, MATERIALS, AND ASSEMBLY

2-1 Frame embers. Depending upon load capacities and frame designs, trailer frame structural members consist of pressed steel channel or box beam side rails, pressed steel channel , or box beam cross members, and steel gusset plates and stiffeners. Chassis structural members consist of longitudinal rails, crossmembers, gusset plates, stiffeners, and plates associated with the kingpin and upper coupler plate. Longitudinal rails can be pressed steel channels, I-beams, or box beams. Crossmembers may be pressed steel channel, Z-section, I-beam or box beams. The corners of some SEMITRAILERS and some brackets are steel castings. In some semitrailer tankers, the tanker barrel is a structural member and carries load. In some van SEMITRAILERS, the van body carries load.

2-2 Frame Materials. Steel composition of frame members, gussets, and stiffeners vary depending upon design limitations such as load capacities, trailer size, assembly techniques, and weight saving requirements. Consequently, the steels used range from hot or cold rolled, low carbon, structural quality types having yield strengths of 30,000 to 36,000 PSI, through the high strength low alloys having yield strengths of 45,000 to 55,000 PSI; the latter offer a weight savings up to 25 percent. Steel compositions used for the lunette trailer frames identified in this technical bulletin are also shown in appendix A. Virtually all steels can be welded. Steels used in semitrailer frames, shown in appendix B, are weldable. Frames fabricated from heat-treated steel may be repaired by welding and reinforcing where possible (See TM 9-237, pages 7-24 thru 27). Similarly all aluminum components of a trailer frame may be weld repaired according J to procedures described in TM 9-237 (pages 7-28 thru 34).

2-3 Frame Assembly. Lunette trailer and semitrailer frame members are assembled with bolts, rivets, or welded joints, or by a combination of these methods.

2-4 Frame Galvanization. Frames that have been coated with zinc (galvanized) to prevent corrosion require special repair procedures. Prior to repair, the zinc coating must be removed After repairs have been completed, the repaired area must be re-galvanized using cold galvanizing spray.

Section III. FRAME DAMAGE AND MAINTENANCE EXPENDITURE LIMITS

3-1 Frame Damage. There are two principal types of frame damage: frame deformation and local damage.

a. Frame Deformation. Frame deformation damages generally are categorized into four types of defects: sway, sags, twist, and diamond. Often a damaged frame will have all four of the deformation defects. A graphic representation of each defect is shown in Figure 6. The frames may be checked for straightness per procedure in 3-1(a) 1 through 4.

(1) Sway. Sway is the frame being bent within the horizontal plane. When looking down on a trailer frame it will show a definite bow. Depending on the direction-of the bow, by sighting vertically along a side rail either its front and rear corners will be readily visible or the rear corner will not be visible.

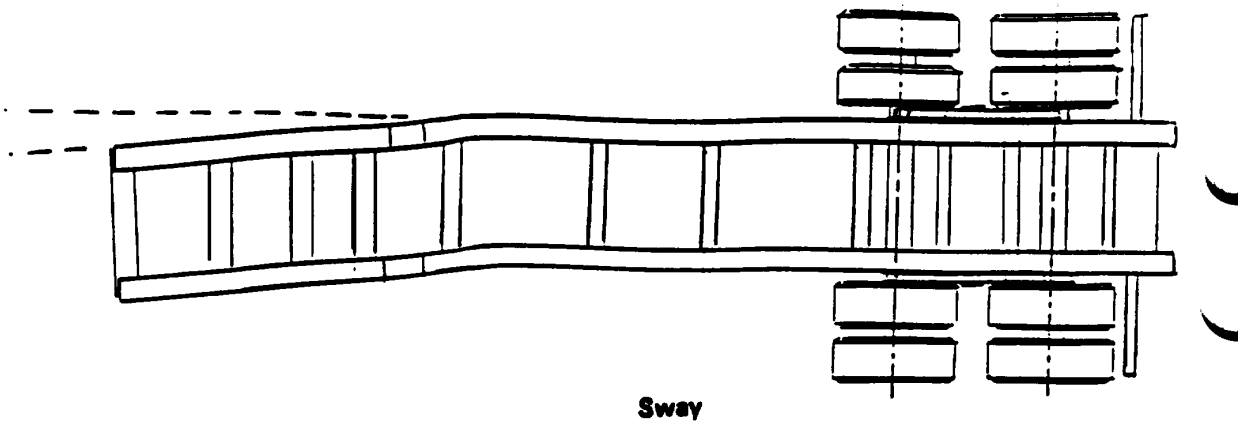
(2) Sags and Humps. Sags and humps occur when the frame is bent within the vertical plane. A sag results when the frame ends have an upward bend. Conversely, a hump occurs when the frame ends bend in a downward direction. When viewing a frame from the side, in a horizontal plane, a hump will show an upward bow, and a sag will show a downward bow between the ends.

(3) Twist. A twist occurs when either the left and right sides or front and rear ends of the frame are bent in different vertical directions. A twist can be easily detected on a flat bed trailer by sighting along the frame horizontally and seeing all four corners; one front and opposite rear corner are bent up, and one front and opposite rear corner are bent down. However, twist is not readily visible on SEMITRAILERS fitted with equipment that prevents a horizontal sighting of all four corners of the bed at the same time. A difference of more than 1 inch between the heights at the front and rear corners indicates twist.

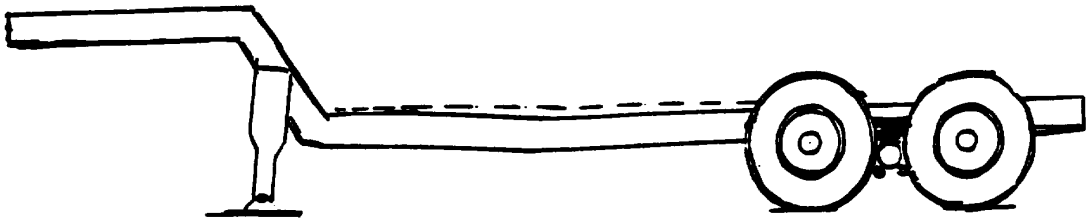
(4) Diamond. The diamond defect, also called rack, results when one side of a trailer's frame has been pushed further forward than the other side, and the frame's crossmembers are displaced out of right angles. Use a builder's square to check all corners. Two or more corners which are not square suggest diamond displacement. A condition of out-of square 0 more than 1/8 inch per foot of semitrailer length confirms that the frame has diamond displacement damage. Generally, when diamond displacement occurs, other damage, such as a bent front crossmember or bent upper coupler supports, exists.

b. Local Damage Cracks and broken welds are categorized as local damage. Cracks are less apparent to the eye than larger deformations of the frame. Close inspection is often required to find cracks, especially if the frame is dirty. Broken welds usually start with a crack and eventually turn into a complete separation.

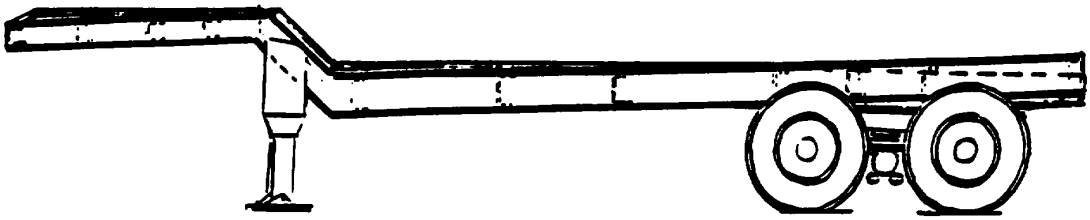
Minor cracks in non-critical areas can be repaired with no detrimental effects on the frame. Repair a cracked or broken member of a frame by preparing and welding the crack/break and



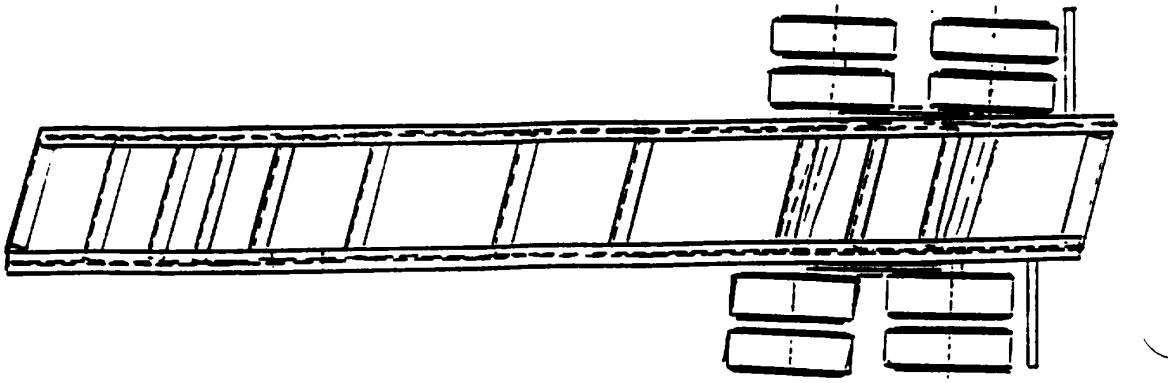
Sway



Vertical Humps and Sags



Twist



Diamond

Figure 6. Frame Deformation Diagrams

then adding a reinforcing plate. The original strength of the member cannot be restored by welding the crack/break alone. The reinforcing plate can be internal, external, or a combination of both on a frame channel member (see Appendix C).

(1) Cause of damage. The type of repair for a cracked or broken weld depends on whether the damage resulted from normal service or from a single accident (collision or explosion). Damage resulting from normal service (fatigue through normal wear and tear) indicates an inadequate weld joint/component design. In such cases the repair must add a reinforcement for greater strength. On the other hand, to repair accident-related damage the weld joint/frame member must be restored to its original strength.

(2) Critical areas. Critical areas of semitrailer frames include king pin supports and upper coupler plate, gooseneck and adjacent areas, and suspension mou nting brackets and adjacent areas, lunette and draw bars (lunette trailers). If the crack is in a critical area, do not repair by welding and reinforcing. The ends of the reinforcement plates are typical stress concentration areas, and will cause additional cracking. If cost effective, cracks in critical areas should be eliminated by replacing the entire cracked segment. If a suspension mount or another component cannot be installed after adding the reinforcing plate, consider replacement of the segment or the entire member.

(3) Beam size. SEMITRAILERS frequently have main longitudinal beams, which are relatively large, and minor rails, which are of smaller cross section. Smaller cross section beams can often be completely replaced.

c. Multiple Cracks. Multiple cracks in close proximity may indicate a frame which cannot be safely repaired. Similar cracks on the right and left side of the vehicle are also suspect. It may be more cost effective to replace the entire rail when multiple cracks are present in a single rail.

d. Corrosion. Deterioration caused by corrosion of the metal frame structure is probably the most common single defect in any frame. It can be the result of a single or a combination of causes such as age, inadequate maintenance, electrolysis, improper design, or a lack of protective finish. In some cases, such as deep pitting and scrapes, deterioration is easy to detect and measure. In other cases, such as corrosion with age, it is impossible to establish the degree of deterioration without a thorough examination. Measure the thickness of corroded members and compare it with the thickness of similar undamaged members. After detecting deterioration and determining its degree, evaluate and determine to what extent repairs are necessary.

(1) Overall frame corrosion deterioration is an indication of inadequate maintenance or improper application of the protective coating system. The extent (area) of corrosion deterioration and loss of material thickness must be measured. A 10 percent loss of frame material thickness is approximately a 10 percent loss of frame strength. Strength losses of up to 15 percent can be tolerated as long as not located.at the high stress areas: suspension support points, mounting brackets, or points for carried loads. When overall loss of material thickness

is 15 percent or less, remove all corrosion and old paint and treat and repaint the frame as originally specified. Frames having more than 15 percent overall loss of material thickness are non-repairable, and should be scrapped.

(2) Localized corrosion deterioration in a frame is an indication of inadequate structural strength at a specific location. Localized corrosion deterioration begins with excessive metal flexing, continues with cracking of the structure's protective coating and admittance of moisture, and ends with the resulting corrosion damage. Localized corrosion deterioration may occur as deep pits in a specific area, along the edges of structural shapes, and in bands or belts around welded or bolted joints. Depending upon the degree of deterioration, repairs range from cleaning, treating, and strengthening the stressed area to replacing a frame segment.

b. Local Damage. Local damage is complete fracture or cracks in frame members or joints. This also includes localized damage caused by an accident. Cracks are less apparent to the eye as are serious deformations of the frame. Close inspection is often required to find frame cracks, especially if the frame is dirty.

3-2 Maintenance Expenditure Limits

a. Permissible Repair Costs for Lunette Trailers and Semitrailers. There is a maximum limit on the total repair cost for a damaged trailer; Normally, a damaged lunette trailer or semitrailer shall be not be repaired whenever its estimated repair cost exceeds its maximum permissible repair cost.

b. Maximum Permissible Repair Cost Procedures. Detailed procedures for calculating the maximum permissible repair cost for lunette trailers and semitrailers are included in TB 43-0002-81, Maintenance Expenditure Limits for Tactical Wheeled Vehicles, FSC Group 23, FSC Classes 2320, and 2330.

c. Estimated Repair Costs. Estimated repair costs can be calculated only after a damaged trailer has undergone a technical inspection to determine the extent and types of.damage. The estimated repair cost also includes freight charges. Procedures for calculating an estimated repair cost are also given in TB 43-0002-81.

d. Technical Inspections. Structural frame repairs technical inspections shall be performed only by persons experienced with the structural frame repair and alignment procedures and shall be checked against trailer frame technical drawings to ensure dimensional accuracy.

Section IV. FACILITIES, EQUIPMENT, TOOLS, AND SKILLS

4-1 General. At present, there are no government or industrial standards relating to frame straightening. Some companies have developed their own standards and a range of equipment and tools to accomplish frame straightening economically and satisfactorily. Industrial standard (SAEJ875) outlines trailer axle alignment inspection checks and limits. (See Appendix F).

4-2 Facilities. The basic requirement for a frame straightening facility is a covered weatherproof structure with adequate lighting, creature comforts, electrical, pneumatic, and hydraulic power sources, and a reinforced concrete floor at least 8 inches thick. The floor should be capable of having engineered tie-downs inserted into it, and be capable of withstanding pulls of up to 50 tons. Anchor equipment or trailer elements to the tiedowns as required. A trailer alignment facility only requires a flat and level floor. Facility floor spaces should be sufficient to allow full movement of the largest trailer authorized for repairs.

4-3 Tools and Equipment. Use only equipment authorized by a Table of Organization and Equipment (TOE) or a Modification TOE (TOE). The TOE/MTOE shall include commercial frame straightening equipment, as well as equipment for cutting, bending, drilling, and welding steel sheets/plates and shapes of not more than 1 inch thick.

4-4 Skills. Standard metal working, welding, and automotive mechanic skills are required to perform basic frame and suspension system repairs. The Military Occupational Specialty (MOS.) required to perform these repairs is MOS. 44B (MOSC 44B10 [Organizational] and MOSC 44B20 [DS/GS]), Metal Worker.

Section V. FRAME STRUCTURE REPAIR PROCEDURES

5-1 Frame Members and Segments

a. General. A frame member is a single part of the frame fabricated from a channel, Z, I-beam, or box beam. It can be a side rail or a crossmember. A segment is a given length of a frame member. Damaged, non-repairable segments may be cut out of a member and new replacement segments added in their place.

b. Repair Planning. When planning a frame repair, first identify the damaged member/segment causing the greatest frame distortion. Develop a repair method to eliminate that distortion. Continue to plan by identifying the next greatest distortion and developing a repair method for its elimination. Successively eliminate the causes of each frame distortion until all remaining distortions and repair methods have been identified. Whenever a member or segment is removed for replacement or repair, other damaged members shall be straightened before installing the replacement or repaired member or segment.

c. Damaged Frame Members.

(1) Bolted Members. Remove and replace or repair damaged bolt-on frame members. Attach the repaired/replacement member to the frame according to the repair plan.

(2) Riveted Members. Depending upon the extent of damage, a riveted-on frame member should be removed, repaired/replaced and then reinstalled using correct size new bolts in place of the rivets.

(3) Welded Members. Depending upon the extent of damage, a welded-on frame member may be cut out and replaced or repaired while in place. Cutting may be accomplished by grinding. If material is to be cut by carbon arc air gouging, remove CARC paint from the heat-affected area using an appropriate wire wheel and respirator.
s shall be made by certified steel and/or aluminum welders.

d. Welding Requirements. There are five basic requirements for frame welding repairs:

(1) All weld shall be made by certified steel and/or aluminum welders.

(2) Use arc welding procedures for joining weldable steel and aluminum members.

(3) Use filler materials that matches the parent metal.

(4) Use intermittent (skip) welds to allow for proper joint cooling, to minimize concentrations of internal stresses resulting from welding, and to avoid frame warping. Size, length, and space between welds will be specified in the trailer Frame drawings.

(5) Round all welded corners to avoid stress risers and subsequent weld cracks.

In addition, MIL-STD-1261C(MR), 20 January 1988, prescribes the classification and welding processes used in arc welding construction steels, and shall be made available to welders. It contains updated information to cover the state-of-the-art by including additional welding i processes with referenced matching filler metal to reflect current industry practices.

e. Bolts and Rivets. Use new bolts, washers, and locknuts when installing repaired/replaced members. Remove rivets with an appropriate tool, such as the rivet buster, and replace with a new bolt, washer, and nut. Ream the rivet hole to the proper size for the replacement bolt. (The *rivet buster* may be fabricated from a 7/8 or 1-inch cold chisel ground to an edge of approximately 55'. The point should be ground to have a flat side that rests on the surface of the component. Attached to an air hammer, it makes a very efficient tool for removing rivets without damaging the hole.)

In bolted repairs, more plate should be used compared to welded repairs, to compensate for comparatively lower strength of a bolted configuration. Bolt spacing and diameter are critical for producing a strong joint design. Bolt spacing should not be less than 3 inches center to center for up to 1/2 bolt size, that is the most commonly used bolt for trailer frame repairs.

f. Buckled, Wrinkled, Mangled Segments. Do not straighten segments of members which are buckled, wrinkled, or mangled. Members and/or segments with this type of damage must be replaced. Metal damaged this way stretches greatly at each bending point; its original strength cannot be restored even though it can be restored to its original shape. It may be more economical to remove the member with the damaged segment and replace the entire member, rather than attempting to replace the damaged segment only.

5-2 Frame Straightening

a. Temperature Conditions. Straighten the frame under ambient and uniform temperature conditions; that is, do not apply any external heat. A non-uniform temperature within the section being straightened will create internal stresses, result in a non-uniform bend back, and reduce the frame's strength.

b. Stresses/Stressing. Every bend in a frame or member is the result of the metal being stressed beyond its yield strength. Therefore, to cold straighten a frame the metal is again stressed beyond its yield strength, but in the opposite direction. When restored to its original shape the metal still retains its original characteristics. However, repeated bending of the metal beyond yield strength will ultimately cause it to fail as a result of work hardening fatigue. Inspect frame visually for local or overall damage using frame alignment methods in Section VI, Axle Alignment Procedure, and frame drawings to ensure accuracy.

c. Inspection, A careful frame inspection will determine which members/segments are damaged, to what extent, in which direction, and over what length. The results of the inspection are used to make a frame repair plan that, based on the skill and experience of the repair personnel, outlines the sequence of the operations needed to repair a damaged frame.

d. Application of Straightening Forces. To straighten a bent frame member, bend it back beyond its original straight form to allow the metal to spring back to the original straight form. To avoid over-bending, the initial straightening force applied should be only enough to bring the frame member back to its straight form. Remove the force and measure the spring-back. Re-apply sufficient force to bend the member beyond "straight" by the amount of measured spring-back. Remove the force and check the member for straightness. Repeat this procedure as necessary until the bend has been eliminated and the member is in its original straight condition.

5-3 Frame Welding

a. Remove Structure Load. The first step to repair a weld joint is to remove the structural load from members, member segments and the joint requiring repair. Use jack stands or other cribbing to safely support both sides of the damaged weld joint. Also place supports at other points to ensure that the frame and members cannot move when old welds are removed.

b. Align Members. Position members of the damaged segment or joint for proper alignment or fit. Adjust or shim jack stands and cribbage to obtain proper alignment of members or segments and to close cracks. Broken pieces of segments shall touch each other. Measure and record type, size, and extent of each damaged weld that is to be removed for repair.

c. Prepare Weld Joints/Crack. Remove old weld material from the welded joint or the crack. Where groove welds are to be used, remove material to be replaced from members or segments. Use a portable grinder of suitable size to make a bevel groove along the length of the

crack. For cracked welds, remove all weld material for 1 inch beyond the crack. Similarly, remove all paint down to the bare metal for a distance of 4 inches from where new welding is to be done, including the back and inside of all metal surfaces to be welded.

d. Weld Joint/crack. Reweld the damaged joint using the skip weld procedure where appropriate(paragraph 5-1d). For small cracks fill in the bevel groove along the length of the crack with weld in accordance with TM 9-237 procedures.

e. Strengthen Weld Joint. Weld joints damaged through normal service wear and tear activities shall be strengthened after the weld repair is completed. Also strengthen cracked, broken, or replacement segment weld joints.

(1) Preparation of Weld Joint. Grind the weld flush with parent metal's surface so that a reinforcing plate will fit flush on top of the welded members.

(2) Design of Reinforcing Plate. Use a reinforcing plate of the same material as the frame (see appendix A and appendix B). The plate thickness shall be the same to 1-1/4 times that of the member's thickness. When members are of different materials and/or thickness, the reinforcing plate shall be made of the same material as the member having the least thickness or yield strength. Where necessary, bend the reinforcing plate so that it lies flush on the surfaces of each joined member. Typical flange reinforcement plate designs are shown in figures C-1 and C-2. Typical web reinforcement plates are shown in figures C-3, C-4, and C-5. (See appendix C.)

(3) Fabricate reinforcement. Fabricate reinforcement plate(s) according to the repair design selected.

(4) Install Reinforcement. Clamp the reinforcement plate in position and weld using the skip-weld procedure specified in paragraph 5-1d.

f. Treat/Paint Repair Joint. New members or segments, weld joints, and reinforcement plate areas shall be sanded, re-primed per MIL-P-53030 or MIL-P-53084, 1.0 to 1.5 mils dry film thickness, and topcoated camouflage basecoat, green 383, color 34094, or tan 686, color 33446, per MIL-C-46168 or MIL-C-53039, 1.8 mils minimum dry film thickness. Camouflage pattern coat as required, brown 383, color 30051 and/or black, color 37030, per MIL-C-46168 or MIL-C-53039, 1.0 mils dry film thickness.

g. Cracked/Broken Weld Joint. The type of repair for a cracked or broken weld depends on the cause of the damage. Damage resulting from normal service (fatigue through normal wear and tear) indicates an inadequate weld joint design. In such cases the repair needs to have a reinforcement added for greater strength. The repair for accident-related damage only needs to have the weld joint restored to its original weld strength. Cracked or broken original reinforcing plates must be removed and replaced with new plates of the same design and material rather than weld repairing the crack.

h. Cracked/Broken Member. Repair a cracked or broken member of a frame by preparing and welding the crack/break and then adding a reinforcing plate for extra strength. The original strength of the member cannot be restored by welding the crack/break alone. The reinforcing plate can be internal, external, or a combination of both on a frame channel member. If a suspension mounting or mounting of another item cannot compensate for or permit addition of the reinforcing plate, replacement of the entire member shall be considered. The frame shall be considered as non-repairable when member replacement is not practical. Where repair of the cracked/broken member is practical, proceed as described in steps a-g above.

5-4 Repairing/Replacing Deformed Member. Frame members deformed in a local area resulting in metal thickness reduction are also reduced in strength. Straightening such members cannot restore metal to its original thickness. Original strength cannot be restored; therefore, deformed members shall be removed and replaced. Similarly, at times it may be more economical to replace the frame member rather than cut out a damaged segment, and fabricate, insert, and strengthen a replacement segment.

a. Complete Member Replacement. Complete frame members shall be replaced as follows.

(1) Remove Structural Load. The first step to remove a complete frame member is to remove its structural load. Use jack stands or other cribbing to safely support all frame members that connect to the member to be replaced. Support the frame at other points to ensure that the frame and its members cannot move with removal of damaged members.

(2) Remove Damaged Member. Before their removal, measure and record all welds by type, size, length, and location. For a welded frame member, remove old weld material from all welded joints holding the member. Use a portable grinder of suitable size. Avoid application of excessive heat to the remaining frame members. Also remove all paint down to the bare metal a distance of 4 inches from where new welding is to be done, including the back and inside of all metal surfaces to be welded. For galvanized trailers, the galvanization must first be ground off. Wear an appropriate respirator and remove zinc coating using a suitable grinder.

(3) Realign Remaining Frame Members. Align remaining frame members to their correct original positions. Repairs to some existing member may be necessary before the remaining frame members can be correctly aligned.

(4) Fabricate/Obtain Replacement Member. If feasible, obtain a replacement member. If not, fabricate the replacement member to the design of the original member. The finished member's length can be easily determined by measuring similar members. Member material shall be the same as the original member (see appendix A and appendix B).

(5) Install Replacement Member. Clamp the replacement member in position and weld using the skip-weld procedure specified in paragraph 5-1d.

(6) Treat/Paint New Joints. Treat and paint replacement member and welds

according to the requirements of drawing No. 19207-12355846-400.

(7) Re-galvanize Repairs. Apply cold galvanization spray to previously galvanized surfaces that have been repaired.

b. Segment Replacement. When segments can be replaced without the removal of a frame member, use the following procedure:

(1) Remove Structural Load. The first step to remove a frame member's segments to remove the structural load from the member. Use jack stands or other cribbing to safely support all attachment points of the damaged segment and the remaining segment. Also place supports at other points to ensure that the frame and its members cannot move with removal of the damaged segment.

(2) Remove Damaged Segment. Cut and remove the damaged segment and old weld material from all welds holding it. Use a portable grinder of suitable size. Avoid application of excessive heat to the remaining frame members and segments.

(3) Realign Remaining Portions of Frame Members. Align the remaining frame members and segments to their original correct positions. Some member repairs may be necessary before proper alignment can be obtained.

(4) Fabricate Segment and Reinforcement Plates. Fabricate the replacement segment to match its frame member's design. The member's length can be easily determined by measuring similar members. Segment material shall be the same as the original member (see appendix A and appendix B). Design and fabricate reinforcement plates. Reinforcement plates shall be of the same material and have a thickness the same to 1-1/4 times that of the member. Typical plate designs are shown in figures C-6 and C-7.

(5) Install Segment and Reinforcement. Clamp the replacement segment in position and weld using the skip-weld procedure specified in paragraph 5-1d. The weld joint connecting the new segment to the existing segment shall be a full depth groove weld, ground flush with the parent metal's surfaces so that the reinforcing plates will fit flush on top of the welded member's segments.

(6) Treat/Paint Repair. Treat and paint replacement segment, welds, and reinforcement plates according to the requirements of drawing No. 19207-12355846-400 (see appendix C).

5-5 Repairing Deterioration Caused by Corrosion

a. Detection and Degree of Deterioration. Deterioration corrosion of the metal frame structure is probably the most common, single defect in any frame. It can be the result of any single cause or a combination of causes such as age, inadequate maintenance, excessive working

of the frame structure, chemical or erosive action, electrolysis, local wear, or an improper design feature. In some cases, such as deep pitting and scrapes, deterioration is easy to detect and measure. In other cases, such as with the general corrosion of age, it is impossible to establish the degree of deterioration without a very careful and thorough examination. In these cases the only practical way of determining the degree of frame deterioration is to measure the thickness of the member in question and compare it to the original thickness in undamaged areas of similar members. After detecting deterioration and determining its degree, judgment is required to evaluate and determine to what extent repairs are necessary.

b. Overall Corrosion Deterioration. Overall frame corrosion deterioration is an indication of inadequate maintenance or improper application of the protective coating system. The extent (area) of corrosion deterioration and loss of material thickness must be determined. An overall 10 percent loss of material thickness is approximately a 10 percent loss of frame strength. Overall strength losses of up to 15 percent can be tolerated as long as there are no signs of greater losses at the higher stress areas: suspension support points, drawbar connection points, mounting brackets, and points for carried loads. When overall loss of material thickness is 15 percent or less, remove all corrosion and old paint and treat and repaint the frame as originally specified. Frames having more than a 15 percent overall loss of material thickness are nonrepairable, and should be scrapped.

c. Localized Corrosion Deterioration. Localized corrosion deterioration in a frame is an indication of inadequate structural strength at a specific location. The course of localized corrosion deterioration begins with excessive metal flexing due to unknown stresses, proceeds successively with cracking of the structure's protective coating system and admittance of moisture, and ends with the resulting corrosion damage. Examples of localized corrosion deterioration are deep pits in a specific area, along the edges of structural shapes, and in bands/belts around welded or bolted joints. Depending upon the degree of deterioration, repairs range from cleaning, treating, and strengthening the stressed area to replacing a frame segment or member. Repairs are accomplished as follows.

(1) Remove Corrosion. Each corroded area shall be thoroughly cleaned down to a bright, bare metal surface. To avoid stress concentrations, all cleaned surfaces shall be free of sharp corners and curves.

(2) Analyze Stressed Areas. Measure the area and residual material thickness of each cleaned corroded area. Use these characteristics to determine the residual frame strength of the corroded area.

(3) Design and Fabricate Reinforcement Parts. Design and fabricate reinforcement parts necessary to strengthen each damaged area. Determine the cross-sectional area of the damaged portion of the trailer and the cross-sectional area of that portion when new. Areas having a frame thickness loss of less than 15 percent shall be reinforced to their original design thickness. When deterioration results in a 15 to 50 percent loss of frame thickness, the thickness of the reinforced area shall be increased to 50 percent more than the original design thickness.

If the thickness loss is greater than 50 percent, each damaged segment/member must be replaced and reinforced by an additional 50 percent of design thickness in the damaged area. Typical reinforcement designs are shown in figures B-1 through B-9.

(4) Repair Members/Segments As Necessary. Corroded members or segments shall first be repaired as shown in paragraphs 5-2 through 5-4. However, the type of corrosion, overall or localized, and its extent (area and residual material thickness) must be considered when determining whether to repair or replace the member or segment.

(5) Attach Reinforcement Parts.. Accurately position and clamp all reinforcement' parts before welding in place. All areas to be welded shall have the old coating system removed to a distance of 4 inches either side of the new weld location. Welds shall be made using the skip-weld procedure described in paragraph 5-1d.

(6) Treat/Paint New Weld Joint. Treat and paint the newly welded joint and/or reinforcement part areas according to the requirements of the original member/segment.

Section VI. AXLE ALIGNMENT PROCEDURE

6-1 Perform Pre-alignment Activity. Before aligning axles, complete all frame structure repairs. Make repairs according to applicable paragraphs of section V. Inspect all suspension items for damage and repair or replace as necessary. Suspension items to be inspected are grouped into three categories: springs, axles, and wheels.

6-2 Normalize Suspension Loading. The trailer's suspension assembly shall be in a normalized (relaxed) working position and free of abnormal stress before making required measurements. Perform the alignment on a level floor. There shall be no load on the trailer other than permanently attached fittings or standard accessories that remain on it at all times.

6-3 Position Trailer. To ensure that the suspension is in a normalized position, keep the trailer on the level floor area and move it back and forth at least two times. The distance moved in each direction shall be no less than one complete wheel rotation. During this back and forth movement do not engage the trailer's brakes.

6-4 Check and Adjust Lateral Position. For all measurements, use a calibrated tape measure. The center line of the axle and the center line of the semitrailer shall be within 1/4 inch of each other. Trailer alignment measurements are shown in figures 7, 8, and 9.

a. Determine Lateral Position. To determine the lateral position of each axle, measure the distance between each wheel (tire sidewalk, rim edge, brake drum edge, brake backing plate) and frame side rail edge or web. The measured dimensions, A and B for each axle, must be within 1/4 inch of each other.

b. Adjust Lateral Position. When the A and B dimensions exceed the 1/4-inch allowance, jack up the trailer frame so that the axle's wheels are off the floor. Loosen the axle mounting bolts and shift the axle one-half of the difference between A and B in the direction of the smaller dimension. Re-tighten the axle mounting bolts and lower the wheels back onto the floor. Recheck the A and B dimensions. Repeat the positioning procedure until the lateral position is correct.

6-5 Check and Adjust Longitudinal Position. The longitudinal (fore and aft) position is a check of the axle's perpendicularly (squareness) to the trailer's center line. The front (No. 1) axle shall be checked and adjusted first. Additional axles are then checked and adjusted using the No. 1 axle as a point of reference.

a. Axle No. 1. Determine the longitudinal position of the first axle by measuring the distance from the lunette (kingpin in the case of semitrailers) to each end of the axle's centerline. The measured dimensions, C and D, shall be within 1/8 inch of each other. When the axle does not have a distinctive feature that locates its centerline, place a piece of masking tap on each hub, measure each hub's diameter, and locate and mark each hub's center on the masking tape with a fine point pen or pencil. If the difference between C and D exceed 1/8 inch, jack up the

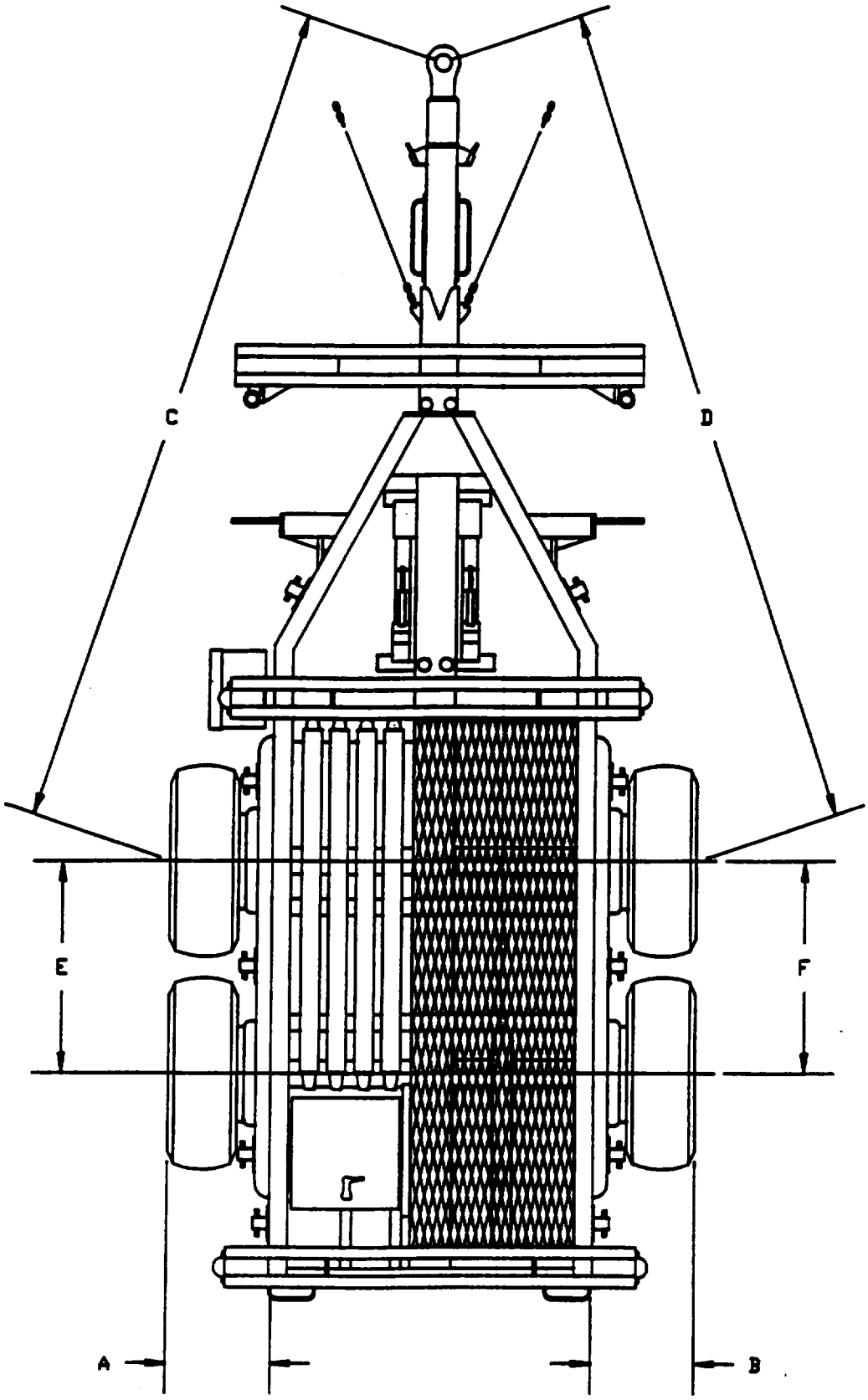


Figure 7. Lunette Trailer Axle Alignment

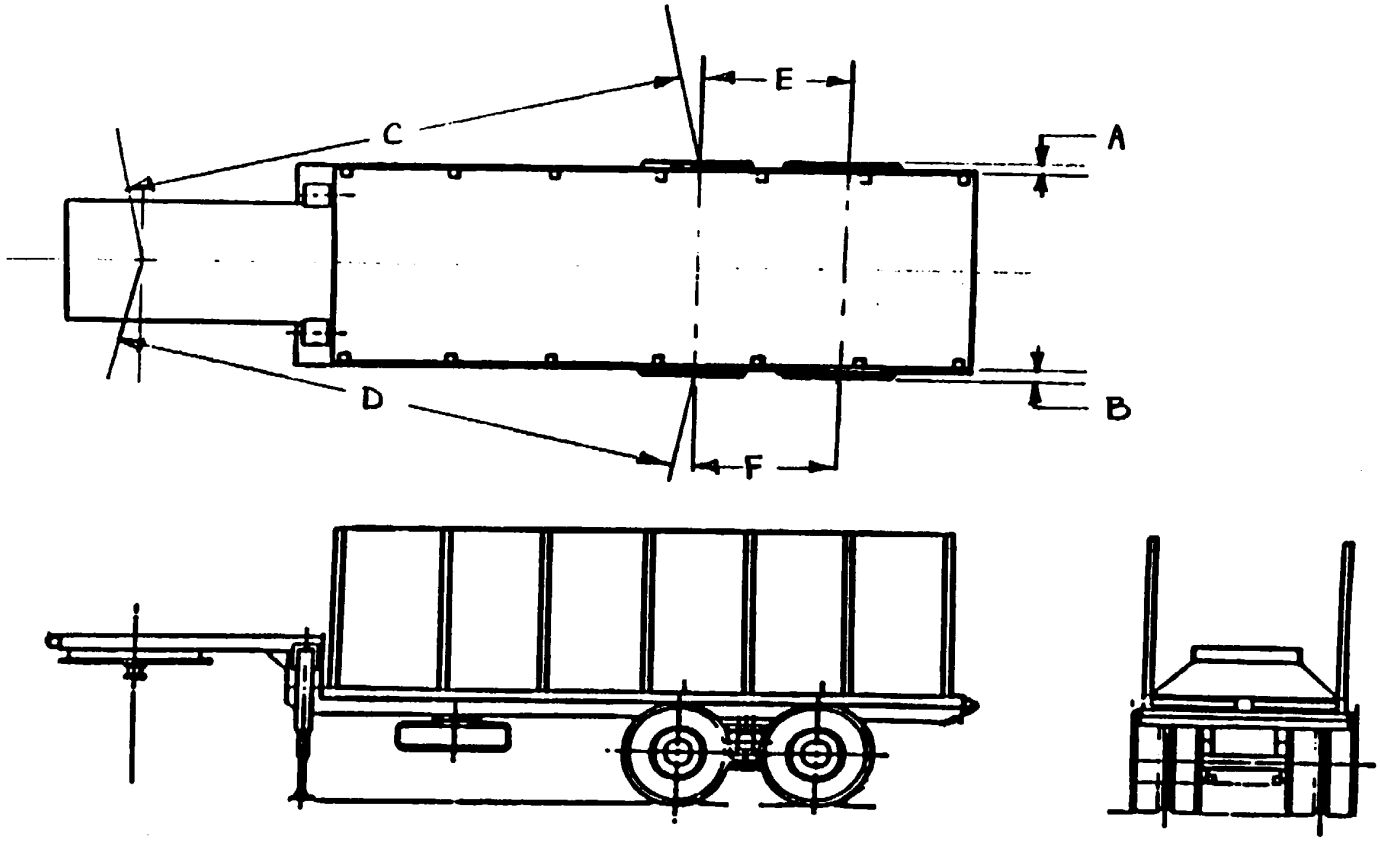


Figure 8. Semitrailer Axle Alignment (Separate Adjustment)

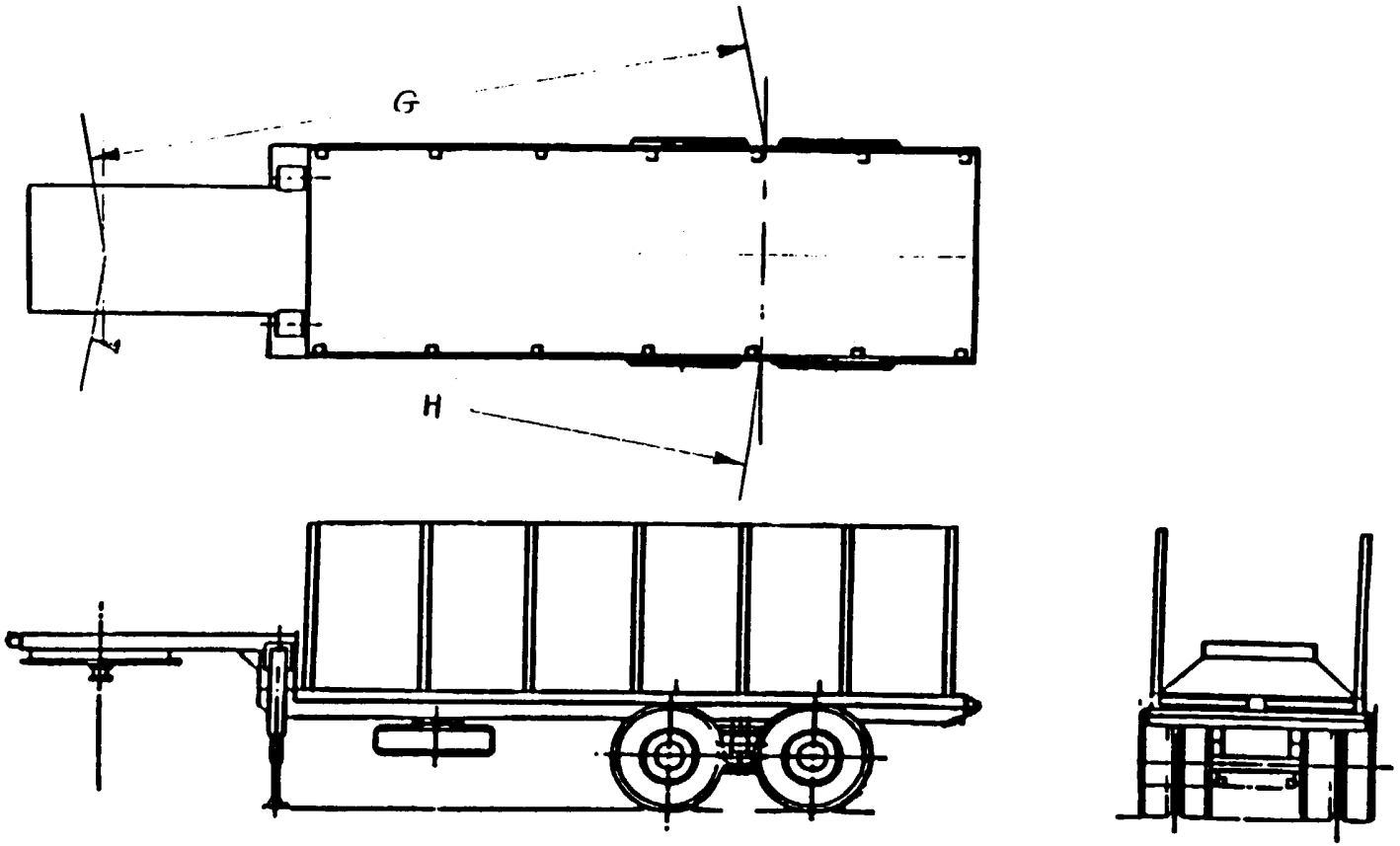


Figure 9. Semitrailer Axle Alignment (Bogie Adjustment)

trailer until the axle's wheels are off the floor. Loosen the axle mounting bolts on one or both sides of the trailer, and move only one side of the axle forward when the side moved has the larger of C or D, and back if the side moved has the shorter dimension. The distance to be moved will depend on each trailer's suspension design. For the first move, a suggested amount may be 0.59 times the difference between C and D. This would be the movement at the spring mount for a typical trailer design. However, it is not necessarily correct for all lunette trailers. Re-tighten the axle mounting bolts and lower the wheels to the floor. Recheck the C and D dimensions. Repeat the positioning procedure as often as necessary until the longitudinal position is correct.

b. **Axle No. 2**. Determine the longitudinal position of axle No. 2 by measuring the distance from the centerline of the first axle to the centerline of each end of the second axle. The measured dimensions, E and F, shall be within 1/16 inch of each other. Again, if the hubs do not have a distinctive feature that locates the axle's center line, locate the line as for axle No. 1. When the difference between E and F exceeds 1/16 inch, jack up the axle's wheels until they are off the floor. Loosen the axle mounting bolts on one or both sides of the trailer, and move only one side of the axle forward for the side having the larger dimension, and to the rear for the side having the smaller dimension. The distance to be moved will depend upon the trailer's suspension design. A suggested distance for the first move is 0.64 times the difference between E and F. This would be the movement at the spring mount for a typical trailer design. However, it is not necessarily correct for all trailers. Re-tighten the axle mounting bolts and lower the wheel to the floor. Recheck the E and F dimensions. Repeat the positioning procedure as often as necessary until the longitudinal position is correct.

c. Axle No. 3. Repeat the procedure for the second axle by measuring from previously aligned axle No. 2.

d. Bogie (Axles not Independently Adjustable). Determine the longitudinal position of each side of the bogie by measuring from the point halfway between the hubs on each side. If this location corresponds to the end of the axle, measure from the end of the axle as shown in figure 9. If the difference between G and H exceeds 1/8 inch, loosen mounting bolts and move the bogie. Repeat the positioning procedure until the longitudinal position of the bogie is correct.

APPENDIX A - LUNETTE TRAILER FRAMES AND MATERIALS

Table A-1. Lunette Trailer Frames and Materials

CHASSIS SIZE/MODEL NUMBER	CHASSIS ASSY DRAWING NUMBER	FRAME ASSY DRAWING NUMBER	MATERIAL
		1/4 TON	
M416	8736401	10924570	Commercial Quality Temper 3-5, QQ-S-698 or Class B GR 2, MIL-S-13281
M416A1	8736996	10924570	Same as previous
M689	8736401	10924570	Same as previous
M716	8736716	10924570	Same as previous
M569	8736401	10924570	Same as previous
M569A1	8736996	10924570	Same as previous
		3/4 TON	
M101	7339476	7339498	HSLA, HR, CR, Class 2, GR 50, ASTM; A607, A606, A715, A572
M101A1	8736398	10910696	Same as previous
M101A2	8750054	10910696	Same as previous
M102	8358589	7979528	Same as previous
M102A1	8358651	7979967	Carbon Steel, HR, CR, PO, Commercial Quality, ASTM; A366 or A569
M102E1	8358650	8384444	Same as previous
M116	7339476	7339498	Same as M101A1 & M102A2
M116A1	8736398	10910696	Same as previous

CHASSIS SIZE/MODEL NO.	CHASSIS ASSY DRAWING NO.	FRAME ASSY DRAWING NO.	MATERIAL
	3/4 TON - CONT		
M116A2	8750054	10910696	Same as M101A1 & M102A2
M762	8736755	10924570	Same as M416
	1 TON		
M514	8736243	8739900	Steel, HSLA, Per MIL-S-13281
M545	8736332	8759940	Same as previous
	1 1/2 TON		
M103A3	8358991	7979967	Same as M102A1
M103A3C	8736246	7979967	Same as previous
M103A4	8358991	8384433	Same as previous
M104A1	8358651	7979967	Same as previous
M105A2	8358991	7979967	Same as previous
M105A2C	8736246	7979967	Same as previous
M107A1	8358654	8384433	HR, CR, PO, Commercial Quality, Temper 3-5, QQ-S-698 or ASTM; A366, A569
M107A2	8358992	8384433	Same as previous
M107A2C	8736247	8384433	Same as previous
M149	8750514	10944279	Same as previous

CHASSIS SIZE/MODEL NO.	CHASSIS ASSY DRAWING NO.	FRAME ASSY DRAWING NO.	MATERIAL
1 1/2 TON - CONT			
M149A1	8736829	1625110	HR, CR, PO, Commercial Quality, Temper 2-5, QQ-S-698 or Class B, GR 2, MIL-S-13281
M149A2	8736829	11625110	Same as previous
M332	8358932	10919543	Same as M107A1
M448	8358991	7979967	Same as M102A1
M625	8736834	11625110	Same as M149A1
2 TON			
M390	8736324	10891200	Steel Alloy Tubing, 4130, 8630, 8720, or 5130 per QQ-T-825 or QQ-S-62a
M390C	8736315	10891201	Same as previous
2 1/2 TON			
M200A1	8358998	8699544	QQ-S-635 or MIL-S-13281 or ASTM; A361, A238, Grade Optional
3 1/2 TON			
M271	8342167	8342198	HR, CR, PO, Commercial Quality, Temper 3-5, QQ-S-635
M271A1	8733990	8342198	Same as previous

CHASSIS SIZE/MODEL NO.	CHASSIS ASSY DRAWING NO.	FRAME ASSY DRAWING NO.	MATERIAL
	3 112 TON - CONT		
M310	8358756	7361478	Structural GR C, QQ-S-741 or ASTM A373
M353	8736268	10893121	HSLA, Structural Quality, GR 50, ASTM; A361, A366, A569, A572
	4 TON		
M796	8736831	11636501	Steel, HRPO per ASTM; A569 or Steel CR, Oiled, temper 3-5 per ASTM; A109
M796A1	8750088	11636501	Same as previous
	5 TON		
XM979	12269888	12259707	Steel, Commercial Quality, HR, PO, per ASTM A569 or Steel, CR Exposed Matte Finish Oiled per Spec ASTM A366
M1061A1	8750137	12331749	Same as previous.
M1034	N/A	N/A	Steel, Commercial Quality, HR, PO, Per ASTM A569 or Steel, CR, Exposed Matte Finish, Oiled, Spec ASTM A366

CHASSIS SIZE/MODEL NO.	CHASSIS ASSY DRAWING NO.	FRAME ASSY DRAWING NO.	MATERIAL

6 TON

M1048	N/A	N/A	Steel, Commercial Quality, HR, PO, Per ASTM A564 or Steel, CR, Exposed Matte Finish, Oiled, Spec ASTM A366

7 1/2 TON

M1073	8750227	12357970	Steel, HSLA Per ASTM A514

10 TON

M345	8358914	8733739	Steel, HSLA per MIL-S-13281

11 TON

M989	N/A	N/A	Same as M1048

APPENDIX B - SEMITRAILER FRAMES AND MATERIALS

CHASSIS SIZE/MODEL NO.	ITEM	DRAWING NO.	MATERIAL
6 TON			
M295A1,M313, M373A2, M447	Fame Assy - Chassis Welded Construction	8758752	Steel, Structural, Type II, ASTM A36; Steel, Carbon C1010 to C1025, Spec ASTM-A108; Steel, Structural, ASTM-A36
M348A2	Frame, Undercarriage	10891320	Steel, High Strength, Low Alloy, ASTM A606, Type Optional or ASTM A607, Grade 50; Steel, Low Alloy, Class B, Grade 2, MIL-S-13281, Optional Material Steel, HSLA, ASTM A606 Type Optional or ASTM A607, Grade 50; Steel Low Alloy, Class B, Grade 2, MIL-S-13281
7.5 TON			
M349A3	Frame Assy, Floor	8737137	Aluminum Alloy, 3003-H1A, Spec, QQ-A-250/2; Aluminum Alloy 6061, Temper T-6, Spec QQ-A-200/8
10 TON			
M971	Frame, Undercarriage	11684443	Steel, HSLA, ASTM A606, Type Optional or ASTM A607, Grade 50; Steel HSLA, ASTM A572, Grade 50

CHASSIS SIZE/MODEL NO.	ITEM	DRAWING NO.	MATERIAL

12 TON

M126A1C, M126A2C, M127A2C, M129A1, M129A1C	Frame Assy	8724534	Steel, HR, P&O or CR Commercial Quality temper 3-5, QQ-S-698; Steel Carbon, Structural Shapes, Grade C, ASTM A 373-58T, QQ-S-741; Steel, Carbon Plate QQ-S-741; Steel Structural ASTM A36, QQ-S-741
XM1063	Undercarriage Assy	12353889	Steel Structural, Per ASTM 242 Type 2, Optional Grade B; Steel, HSLA, ASTM A606, Type Optional or ASTM A607, Grade 50

5000 GALLON TANKER

M857A/970, M967/A1, M969/A1, M970/A1, XM1098	Frame, Front	11670786	Steel, HSLA, Class B, Grade 2, MIL-S-13281; Steel, HSLA, Structural Quality, Grade 50, ASTM A572, Optional Steel, Carbon, CD, 1018-1020, ASTM A108; Steel HSLA Type 1 and 2, ASTM A242; MIL-S-12505; Steel, Carbon, Bar Size ASTM A-36, QQ-S-741
M967A1, M969A1, M970A1	Frame, Rear	12275491	Steel, Low Alloy, High Strength, Class B, Grade 2, MIL-S-13281 or MIL-S-12505; Steel, High Strength, Low Alloy, Structural Quality ASTM A572, Optional: Steel, Carbon, CD, 1018-1020, ASTM A108

CHASSIS SIZE/MODEL NO.	ITEM	DRAWING NO.	MATERIAL

22.5 TON

M871/A1/A2 Grade 50 and Steel ASTM A-36	Frame, Main	N/A	Steel, ASTM A-572,

34 TON

M872/A1/A2/A3 Grade 50 and Steel ASTM A-36	Frame, Main	N/A	Steel, ASTM A-572,

40 TON

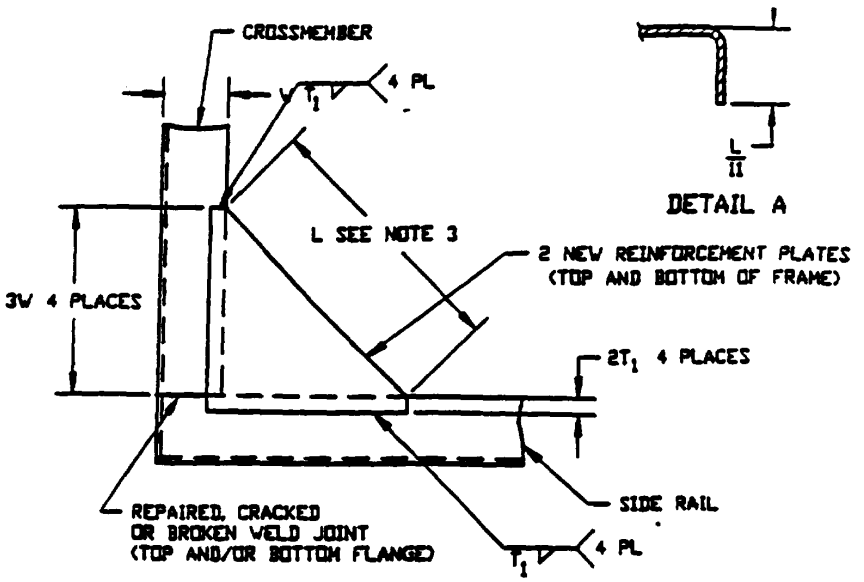
M870	Frame, Main	N/A	Steel, Low Alloy, High Strength, Structural Quality ASTM A514 Grade A
M870A1	Frame, Main	N/A	Steel, Low Alloy, High Strength per ASTM A572 and Steel, Structural ASTM A36

52.5 TON

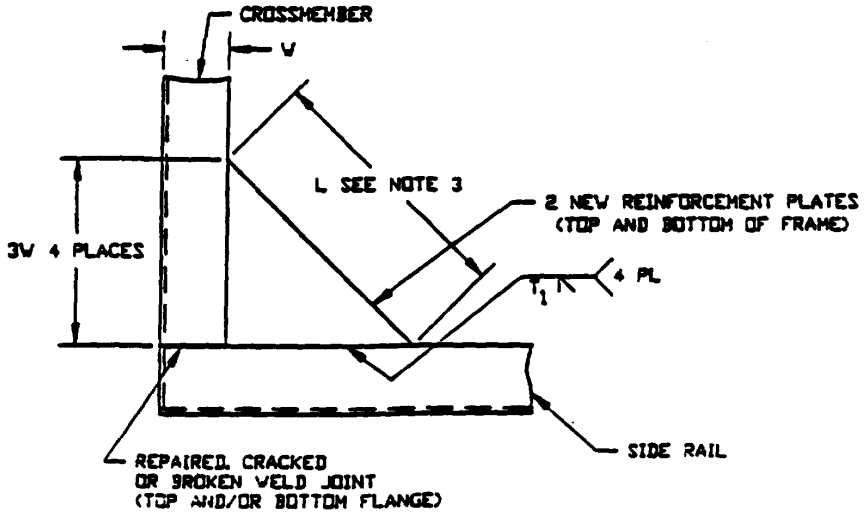
M747	Frame, Main	N/A	High Strength, Low Alloy Per MILES-13281E(MR) T1 Steel

Appendix C

REINFORCEMENT DETAILS



OVERLAP DESIGN (PREFERED)



BUTT DESIGN (OPTIONAL)

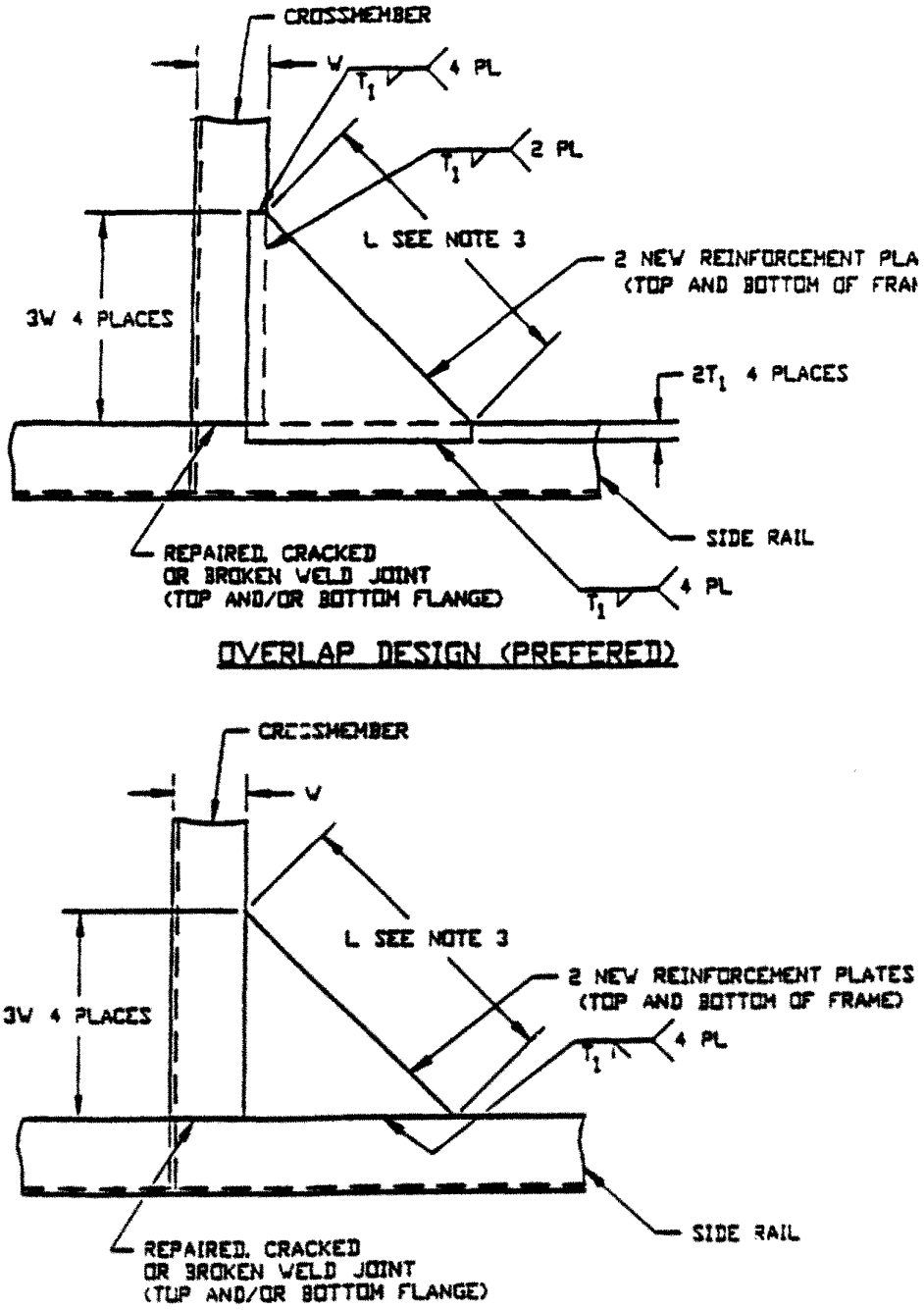
NOTES:

1. **THICKNESS T. OF NEW PLATES IS 1 TO 1 114 MATERIAL THICKNESS OF CROSSMEMBER.**

2. **NEW PLATE DESIGN CAN BE OVERLAP, BUTT OR A COMBINATION OF BOTH. THE OVERLAP CAN BE OUTSIDE OR INSIDE THE CHANNEL FLANGE.**

3. **WHEN LIT, RATIO EXCEEDS 90, STIFFEN NEW PLATE ALONG 'L' EDGE PER DETAIL "A".**

Figure C-1. Corner Flange Weld Joint Reinforcement

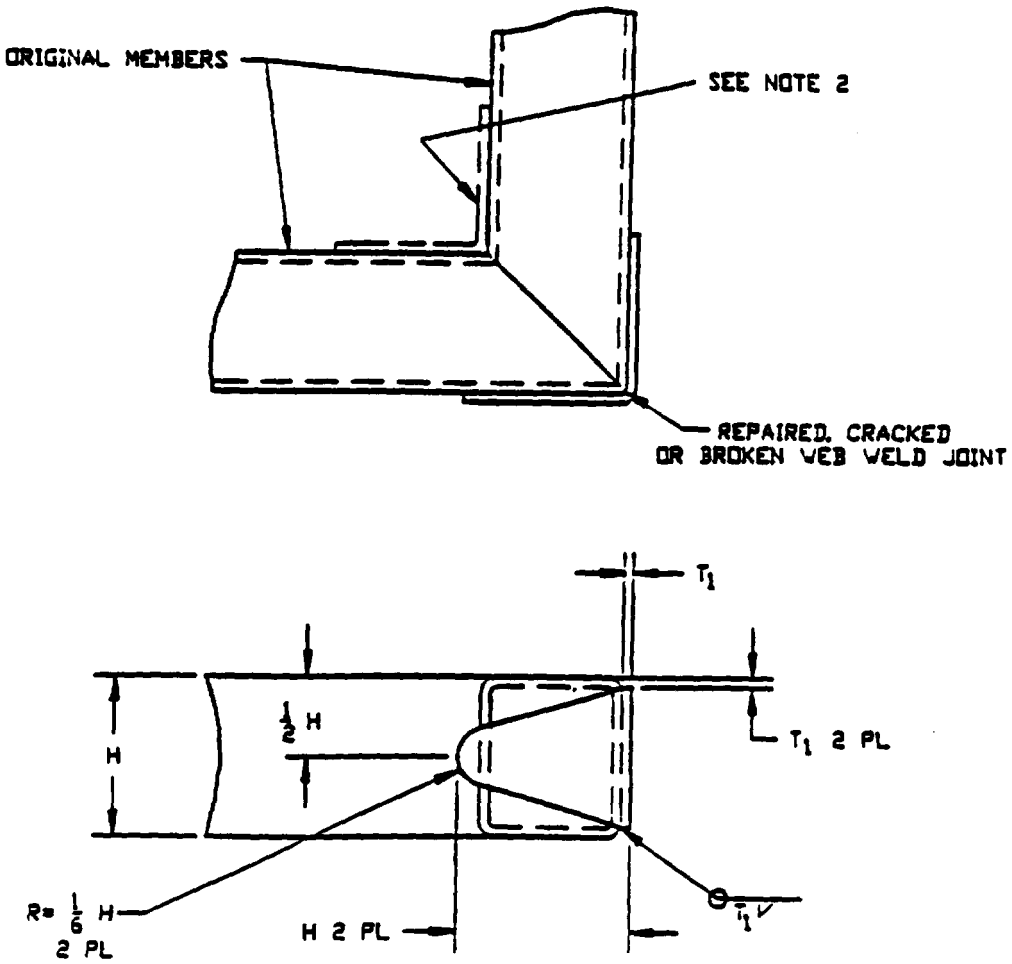


NOTES:

1. **THICKNESS T. OF NEW PLATES IS 1 TO 1 114 MATERIAL THICKNESS OF CROSSMEMBER.**

2. **NEW PLATE DESIGN CAN BE OVERLAP, BUTT OR A COMBINATION OF BOTH. THE OVERLAP CAN BE OUTSIDE OR INSIDE THE CHANNEL FLANGE.**

Figure C-2. Intermediate Flange Weld Joint Reinforcement

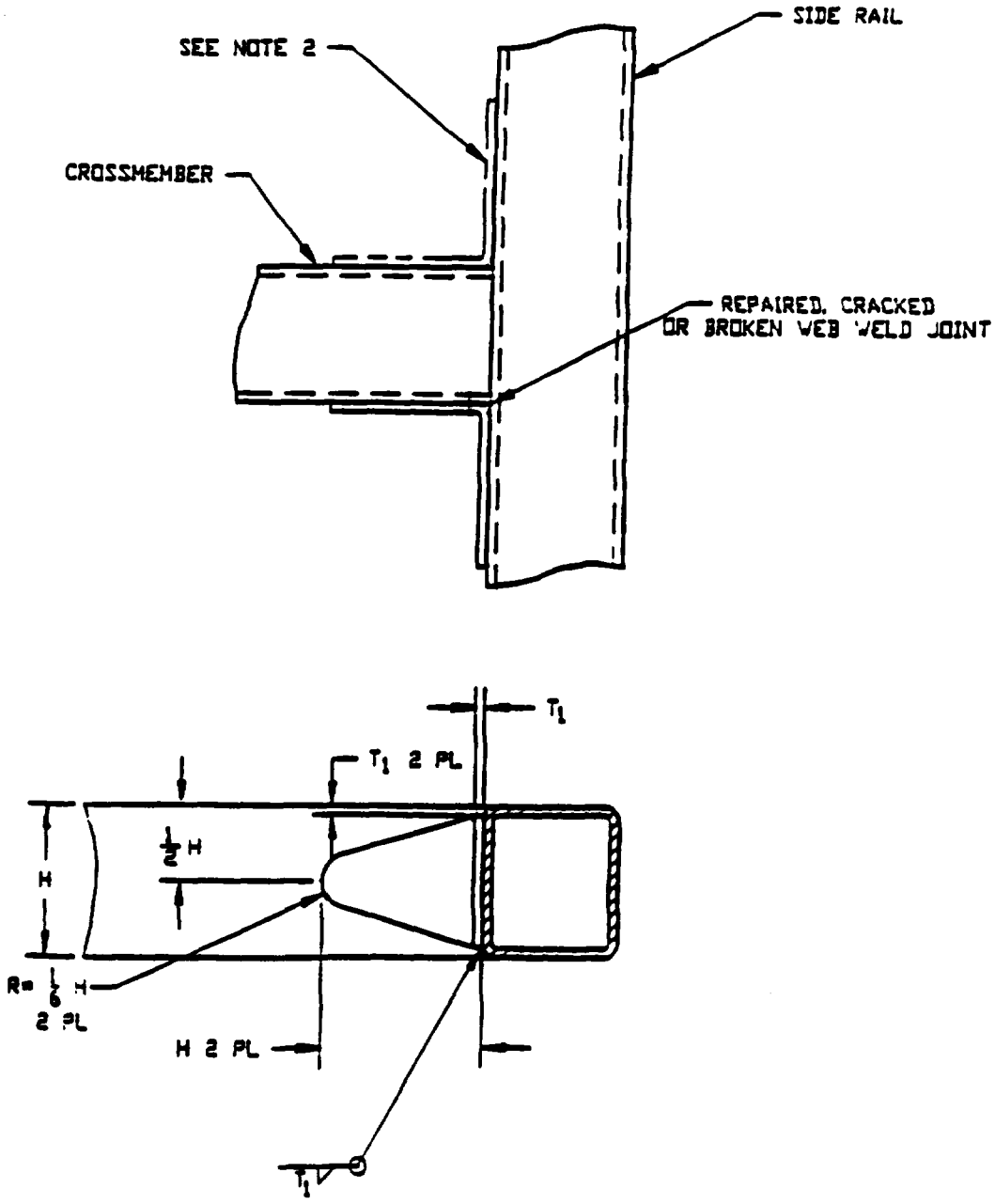


NOTES:

1. **THICKNESS T. FOR NEW PLATES IS 1 TO 1 1/4 WALL THICKNESS OF MEMBER BEING REPAIRED.**

2. **ON BOX TUBE MEMBER, INTERNAL AND EXTERNAL WEB WELDS MAY BOTH REQUIRE A REINFORCEMENT PLATE.**

Figure C-3. Corner Web Joint Reinforcement

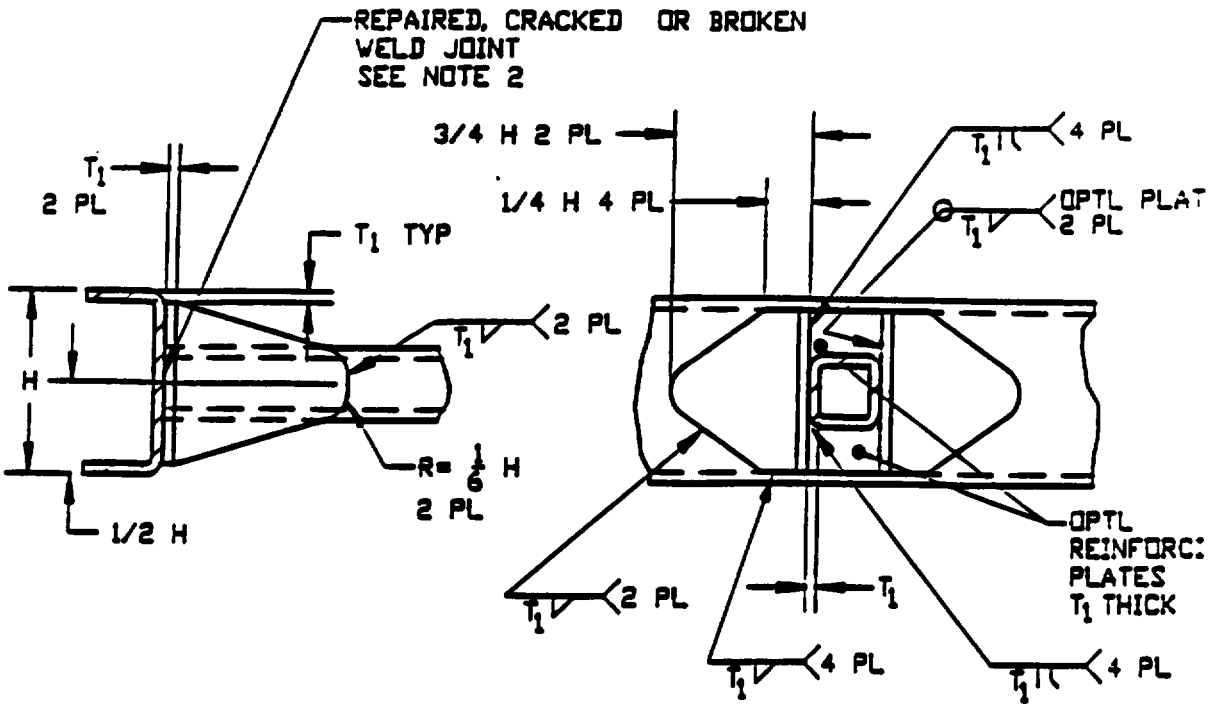


NOTES:

1. **THICKNESS T_1 FOR NEW PLATES IS 1 TO 1 114 WALL THICKNESS OF MEMBER BEING REPAIRED.**

2. **ON BOX TUBE MEMBER, INTERNAL AND EXTERNAL WEB WELDS MAY BOTH REQUIRE A REINFORCEMENT PLATE.**

Figure C-4. Intermediate Web Joint Reinforcement

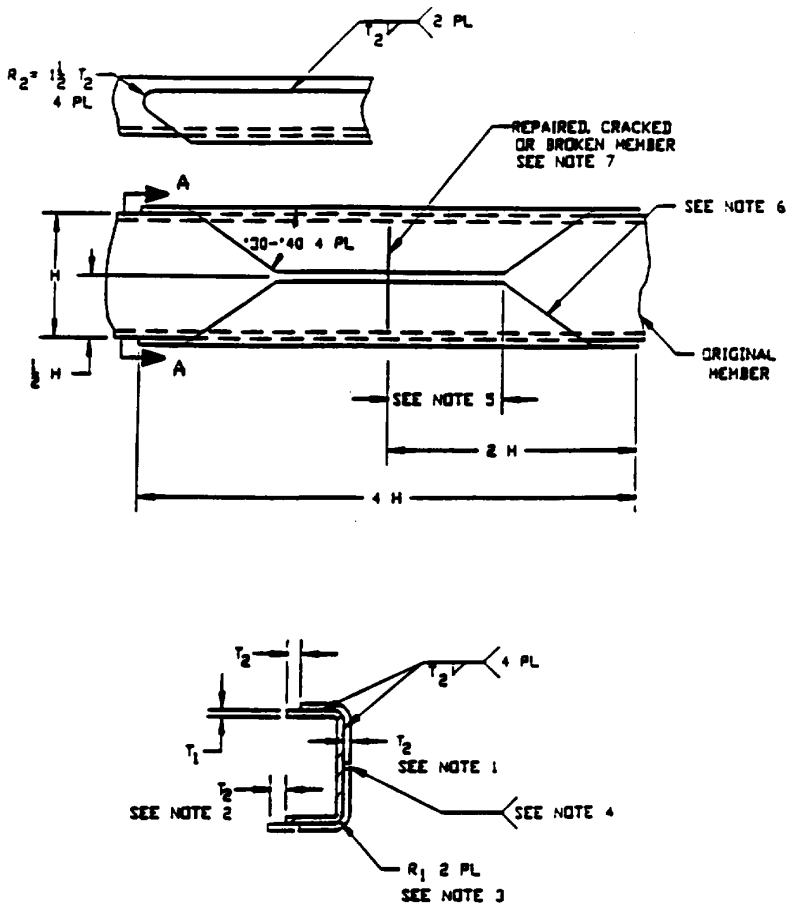


NOTES:

1. **THICKNESS T, FOR NEW PLATES IS 1 TO 1 ¼ SMALLER MEMBER THICKNESS.**

2. **ON BOX OR CHANNEL MEMBERS, TWO ANGLE REINFORCEMENTS ARE NEEDED.**

Figure C-5. Web Weld Joint Reinforcement



SECTION A-A

NOTES:

1. **THICKNESS T2 FOR NEW PLATES IS 1 TIMES T, FOR ACCIDENT REPAIR AND 1 112 TIMES T, FOR NORMAL SERVICE REPAIR.**

2. **NEW PLATE CAN OVERHANG ORIGINAL FRAME MEMBER TO AVOID OVERHEAD WELDING.**

3. **NEW PLATE INSIDE RADII SHALL MATCH OUTSIDE RADII OF ORIGINAL FRAME MEMBER.**

4. **WELD GAP AND WELD TYPE SHALL INSURE NEW PLATES ARE JOINED TO ORIGINAL FRAME MEMBER AS WELL AS BOTH NEW PLATES TO EACH OTHER.**

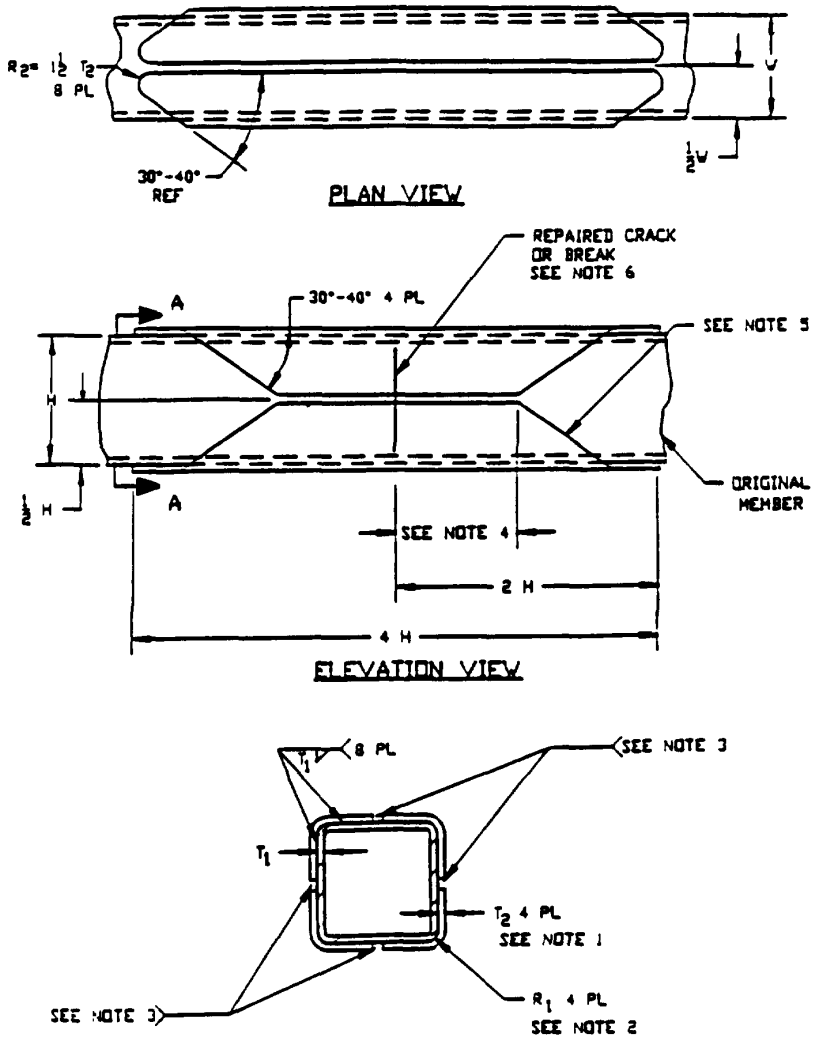
5. **WHERE ASSEMBLY RESTRICTIONS EXIST, LENGTH OF NEW PLATES CAN BE REDUCED WHERE 2H IS 1.12 TIMES 'H" OR MORE ON ONE SIDE ONLY OF REPAIRED CRACK/BREAK AS LONG AS DIMENSION IS 1 112 OR GREATER.**

6. **NEW PLATES SHOULD BE TAPERED FOR GRADUAL LOAD AND STRESS TRANSFER.**

7. **WHENEVER ONE FLANGE ONLY IS CRACKED AND CRACK DOES NOT EXTEND MORE THAN 114 OF "H", ONE REINFORCEMENT PLATE ONLY IS NECESSARY.**

8. **BOTH OR ONE OF THE REINFORCEMENT PLATES CAN BE ON INSIDE OF ORIGINAL CHANNEL DUE TO ASSEMBLY RESTRICTIONS.**

Figure C-6. Channel Member Reinforcement



SECTION A-A

NOTES:

1. **THICKNESS T. FOR NEW PLATES IS 1 TIMES T. FOR ACCIDENT REPAIR AND 1 112 TIMES T, FOR NORMAL SERVICE REPAIR.**

2. **NEW PLATE INSIDE RADII SHALL MATCH OUTSIDE RADII OF ORIGINAL FRAME MEMBER.**

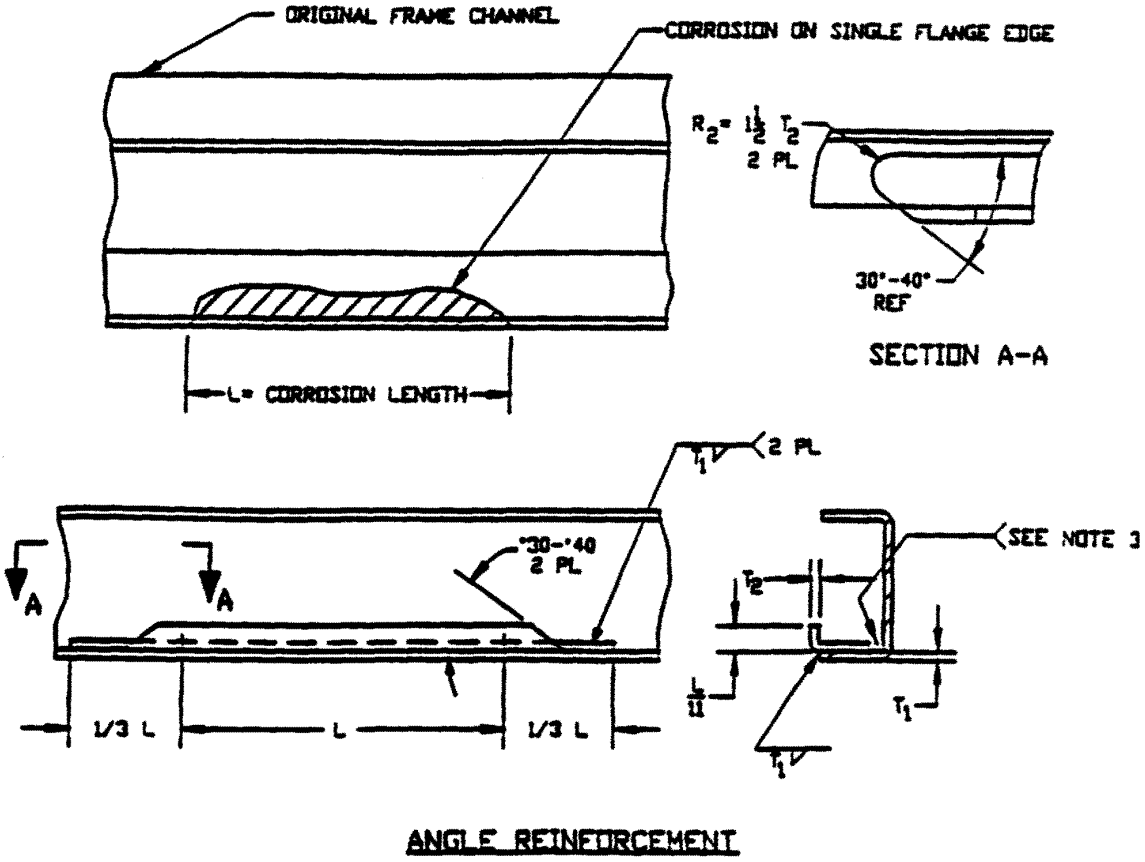
3. **WELD GAP AND WELD TYPE SHALL INSURE NEW PLATES JOINED TO ORIGINAL FRAME MEMBER AS WELL AS BOTH NEW PLATES TO EACH OTHER.**

4. **WHERE ASSEMBLY RESTRICTIONS EXIST. LENGTH OF NEW PLATES CAN BE REDUCED WHERE 2H IS 1.12 TIMES 'H' OR MORE ON ONE SIDE ONLY OF REPAIRED CRACK/BREAK AS LONG AS THIS DIMENSION IS 1 112 INCHES OR GREATER.**

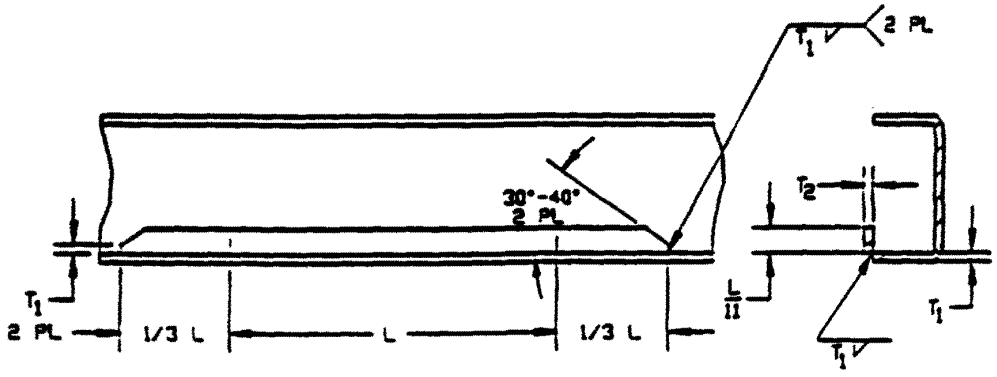
5. **NEW PLATES SHOULD BE TAPERED FOR GRADUAL LOAD AND STRESS TRANSFER.**

6. **ONE OR TWO NEW PLATES MAY ONLY BE NECESSARY WHERE A CRACK IN ANY ONE CORNER DOES NOT EXTEND MORE THAN 114 ALONG DIMENSIONS 'H" OR 'W".**

Figure C-7. Tube Member Reinforcement



ANGLE REINFORCEMENT

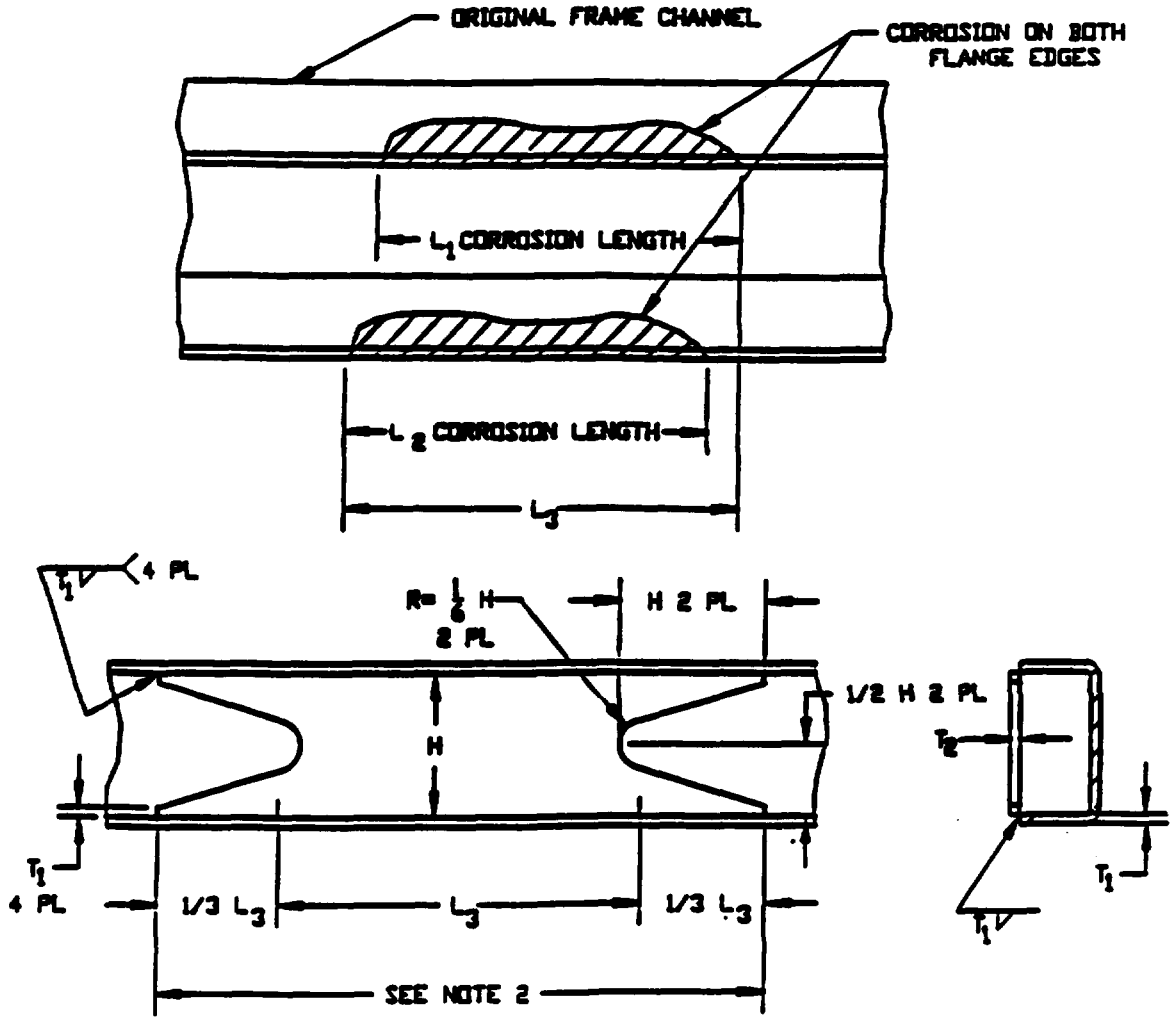


BAR REINFORCEMENT

NOTES:

1. **ANGLE OR BAR REINFORCEMENT DESIGN MAY BE USED.**
2. **THICKNESS T_2 FOR NEW PLATE IS 1 TO 1 1/4 ORIGINAL THICKNESS (T_1) OF FLANGE BEING REPAIRED.**
3. **WELD CAN BE GROOVE OR FILLET AND WELD SIZE EQUAL TO 3/4 T1.**

Figure C-8. Single Flange Reinforcement



NOTES:

1. **THICKNESS T. FOR NEW PLATE IS 1 TO 1 ¼ ORIGINAL THICKNESS (T_1) OF FLANGES BEING REPAIRED.**

2. **MINIMUM LENGTH FOR NEW PLATE IS 3 TIMES "H".**

Figure C-9. Double Flange Reinforcement

Appendix D

DRAWING 12355846-400

APPENDIX D

DRAWING 12355846

TREATMENT AND PAINT SPEC FOR TACTICAL VEHICLES AND COMPONENTS

1. GENERAL

   A. This drawing establishes the minimum painting requirements for chemical agent resistant coatings (CARC) for vehicles and equipment that require camouflage properties in field use.

   B. Unless otherwise specified, the finishing processes and materials shall be selected by the contractor as specified on this drawing and will consist, of cleaning method, surface treatment or metal coating, primer and topcoat. The contractor is responsible to assure that epoxy primers are compatible with polyurethane topcoat. Compatibility/adhesion should be tested prior to use.

   C. Surfaces not to be painted:
   Painting may not be required on certain types of surfaces such as fabrics, plastics, rubber, glass and metal parts not requiring corrosion protection or where paint interferes with function, and surfaces specifically intended for electrical contact or heat transmission.. Unless otherwise specified, these surfaces should be masked or otherwise protected during painting.

2. APPLICATION

   A. Preparation of surface

   Prior to any treatment or painting all surfaces shall be free of soil impurities or corrosion, such as grease, oil, solder flux. welding flux. weld spatter, sand, rust scale, or other foreign matter that might interfere with treatment or painting. Cleaning shall be done immediately before any treatment or painting, or precautions shall be taken to ensure that surfaces remain clean and dry until they are treated or painted. The use of uninhibited alkaline materials (such as sodium hydroxide solution) and abrasives (such as iron oxide rouge and steel wool) that accelerate corrosion of aluminum alloy surfaces is prohibited.

   B. Paint Application

   Primer and topcoat will be applied in accordance with manufactures instructions for mixing, application and cure.

C. Time of Application

The first or priming coat shall be applied as promptly as possible and in any case within 24 hours after the surface has been prepared for painting.

D. Time of Application For Topcoat

The topcoat shall be applied as promptly as possible and in any case within 24 hours after the surface has been primer coated. Any storage during this intermediate period shall be in a controlled temperature and humidity enclosure.

3. Health, Safety and Air Pollution Regulations

A. Paint Qualification

Contractor is responsible to meet all applicable local regulations. When it is necessary to modify paint to meet local regulation requirements, subject paint will be requalified. The activity responsible for CARC qualified product list is the U.S. ARMY Belvoir Research and Development Center, ATTN: STRBEVO, Fort Belvoir, Va 22060

B. High Temperature Paint

Surfaces attaining operating temperature of 400 degrees F must be painted with heat resistant paint.

4. Color Numbers Refer to FED-STD-595.

5. Quality Assurance Provisions (QAP) 12355846 Apply to this Item.

Components/Vehicle Systems Shall Be Cleaned, Treated, Primed and Topcoated in Accordance With The Following:

Cleaning Treatment and Priming

12355846-1 Iron and Steel surfaces (except stainless steel):

Clean per applicable method I thru VI per SPEC TT-C-490. Treat per type I (Zinc Phosphate) or Type III (Wash Primer) SPEC TT-C-490, 0.3 - 0.6 Mils Thick. Apply Epoxy Primer per Spec MIL-P-53022, MIL-P-52030 or MIL-P-53084, 1.0 - 1.5 Mils dry film thickness. Application per MIL-C-53072 (ME).

12355846-2 Stainless Steel and Nickel-Base Alloy Surfaces:

Clean per applicable method I thru VI per SPEC TT-C490. Treat with wash primer per SPEC DOD-P-15328, 0.3 - 0.6 Mils thick. Apply epoxy primer per spec MIL-P-53022, MIL-P-53030 or MIL-P-53084, 1.0 - 1.5 Mils dry film thickness. Application per MIL-C-53072(ME).

12355846-3 Aluminum and aluminum base alloy surfaces:

Clean and treat per spec MIL-C-5541. Apply Epoxy primer per spec MIL-P-53022, MIL-P-53030, or MIL-P-53084, 1.0 - 1.5 Mils dry film thickness. Application per MIL-C-53072(ME).

12355846-4 Galvanized or terne coated steel, cadmium, zinc and chrome plated surfaces or copper, lead and tin alloy surfaces:
Clean per applicable method I thru IV per spec TT-C-490. Treat with phosphate or chromate per spec ASTM D2092 or apply wash primer per spec DOD-P-15328, ASTM D2092 or apply wash primer per spec DOD-P-15328, 0.3 - 0.6 Mils thick. Apply epoxy primer per spec MIL-P-53022, MIL-P-53030 or MIL-.P-53084, 1.0 - 1.5 Mils dry film thickness. Application per MIL-C-53072(ME).

12355846-5 Wood Surfaces:

Clean as applicable, surfaces where pressure treatment was affected, treat per TT- W-572, (no primer required). Application per MIL-C-53072(ME).

12355846-6 Plastic surfaces (polycarbonate, FRP, polyester):

Clean as Applicable. Treat per DOD-P-15328 (optional). Prime per spec MIL-P- 53022, MIL-P-53030 or MIL-P-53084, 1.0 - 1.5 mils dry film thickness. Application per MIL-C-53072(ME).

TOPCOAT

12355846-100 Camouflage basecoat, green 383, color 34094, or tan 686, color 33446, per spec MIL-C-46168 or MIL-C-53039, 1.8 Mils minimum dry film thickness (1.8 - 2.2 Mils for wood). Application per MIL-STD-193.

12344846-101 Camouflage pattern coat as specified, brown 383, color 30051 and/or black, color 37030, per spec MIL-C-46168 or MIL-C-53039, 1.0 Mils dry film t thickness. Application per MIL-STD-193.

12355846-102 Basecoat white, color 27925, per spec MIL-C-46168 or MIL-C-53039, 1.0 mils dry film thickness. Application per MIL-STD-193.

LETTER AND NUMBER MARKINGS

12355846-200 Markings, black color 37030, per spec MIL-C-46168 or MIL-C-53039.

For camouflaged vehicles when black lettering would fall on black camouflaged areas, that portion of the markings shall be brown 383, color 30051. Application per MIL-C-53072(ME).

SPECIAL FINISH

12355846-300 Non-slip surfaces:
Spread walkway compound grit per spec MIL-W-5044 while initial coat is still wet then additional topcoat per 12355846-100. Application per MIL-C- 53072(ME).

12355846-301 Heat resistant paint (surfaces, attaining temperature of 400 degrees F).

Clean by solvent degreasing, grit or sand blasting. Topcoat, color green 383 or forest green per spec MIL-P-14105, 1.5 - 2.5 Mils dry film thickness. Not to be overcoated with CARC. Application per spec MIL-C-53072(ME).

PRODUCTION REPAIR

12355846400 Touch up and repair:

If the coatings are damaged to the substrate, then the area must be sanded, primed per spec MIL-P-53022, MIL-P-53030 or MIL-P-53084, 1.0 - 1.5 Mils dry film thickness and topcoated per 12355846-100. Application per MIL-C- 53072(ME).

Damage not penetrating to the substrate may be recoated with final finish per 12355846-100 after sanding. Application per MIL-C-53072(ME)

12355486401 Surfaces coated with primer or alkyd olive drab or forest green paint:

Clean per applicable method I thru VI per spec TT-C490. Apply epoxy primer per spec MIL-P-53022, MIL-P-53030 or MIL-P-53084, 1.0 - 1.5 Mils dry film thickness. Topcoat per 12355846-100. Application per MIL-C-53072(ME).

RUSTPROOFING

12355846-500 Rustproof per spec MIL-R-46164 with corrosion preventive compound, Type I spec MIL-C-62218.

APPENDIX E - WELD REPAIR

FOR

M747 Trailer Frame And M747 Trailer Ramps

Section I - Purpose of this Appendix E-3
1.1 Introduction E-3
2.1 Scope E-3

Section II - M747 Trailer Frames E-4
3.1 Welding Procedures E-4
3.1.1 T-1 Steel E-4
3.1.2 Pre-Welding Preparations E-4
3.1.3 Preparation of Cracked Areas E-5
3.1.4 Electrode Selection E-5
3.1.5 Preheat and Welding Heat Input E-7
3.1.6 Welding Techniques E-9
3.1.7 Reinforcement Plates E-12
3.1.8 Weld Inspection E-12
3.1.9 Treat/Paint Repaired Joint E-13

Section III - M747 Trailer Ramp
4.1 Welding Procedures E-13
4.1.1 Introduction to 6061 T6 aluminum E-13
4.1.2 Pre-Welding Preparations E-14
4.1.3 Preparation of Cracked Areas E-14
4.1.4 Electrodes/Filler Metal Selection E-16
4.1.5 Welding Process Selection E-16
4.1.6 Shielding Gas Selection E-16
4.1.7 Preheat and Welding Heat Input E-16
4.1.8 Weld Profiles and Joint Requirements E-16
4.1.9 Welding Techniques - Gas Tungsten Arc Welding (GTAW) E-18
4.1.10 Welding Techniques - Gas Metal Arc Welding (GMAW) With Single Electrode E-19
4.1.11 Weld Inspection E-19
4.1.12 Treat/Paint Repaired Joint E-20

Section IV - References E-21

Tables

Table 1. Electrodes Recommended for Welding ASTM A5 14 Steel E-6

Table 2. Suggested Preheat and Interpass Temperatures for ASTM AS 14 Steels E-8

Table 3. Maximum Welding Heat Input (Kj/in) T-1 and T-1 Type Steels E-9

Table 4. Maximum Welding Heat Input (Kj/in) T-1 Steel, Types B and C E-9

Table 5. Permissible Undercut Values E-18

Figures

Figure 1. Straight and Partial-Weave Welding Methods E-10
Figure 2. Wire Spacers E-11
Figure 3. Surface Beads in Filler Welds E-12
Figure 4. Desirable Fillet Weld Profiles E-17
Figure 5. Desirable Groove Weld E-17

SECTION I. PURPOSE

This appendix provides instructions for performing weld repairs to the M747 trailer. Section II covers repairs to the trailer frame and gives instructions for welding T-1 steel. Section m covers repairs to the trailer ramps and gives instructions for welding aluminum.

1.1 INTRODUCTION

Section II of this appendix provides a review of weld procedures to be used in the repair of M747 trailer frames. The M747 frame is fabricated from T-1 Steel, a high strength, quenched and tempered, structural alloy steel. T-1 steel frame members can be welded satisfactorily providing that proper procedures are followed.

The following are the most critical elements of successful T-1 steel repair welding: (1) use of the correct electrodes, (2) appropriate heating, and (3) proper welding techniques. Arc-welding processes, including shielded metal-arc, gas metal-arc and gas tungsten-arc, are acceptable methods for welding T-1 steel.

Section m of this appendix provides a review of weld procedures to be used in the repair of the M747 trailer ramp. The M747 ramp is fabricated from 6061 T6 aluminum alloy in accordance with QQ-A-200/8, QQ-A-200/11, and QQ-A-200/20. This material may be welded, but proper welding practices must be followed to prevent distortion and loss of strength in the base metal surrounding the weld area. Aluminum weld repairs should be made using the correct electrodes, filler metal and appropriate heat input. Gas Metal-arc and gas Tungsten-arc welding are the preferred welding processes for welding 6061 T6 aluminum.

2.1 SCOPE

The weld procedures in Section II apply to maintenance and repair welding of the M747 trailer frame and pertain to damage such as weld/joint failures, cracks/tears in base metal members, and frame reinforcement. This appendix addresses T-1 material properties, cutting and preparing frame members for welding, electrode selection, preheating and heat input, welding techniques and post-weld inspection. The weld procedures in Section m apply to maintenance and repair welding of the M747 aluminum ramp frame and pertain to damage such as cracks/tears in the base metal, weld/joint failures, and frame reinforcement. This appendix addresses 6061 T6 aluminum characteristics, preparation of ramp frame members for welding, electrode selection, preheating and heat input, welding techniques, and post-weld inspection. Arc-welding processes, preferably gas metal-arc and gas tungsten-arc, are acceptable methods for welding 6061 T6 aluminum.

SECTION II M747 TRAILER FRAMES

3.1 WELDING PROCEDURES

3.1.1 T-1 Steel. "T-1" (formerly a United States Steel trademark) is a high strength quenched and tempered alloy steel which conforms to ASTM A514 specification requirements. The T-1 steel alloy composition and heat treatment combine to produce favorable mechanical and physical properties such as:

- high yield and tensile strength:
- good toughness:
- ductility:
- corrosion resistance:
- weldability.

In order to maintain these properties, proper welding procedures and cautions must be followed. T-1 steel welds on the M747 trailer should not be subjected to post-weld heat treatment, which may cause loss of material strength, loss of toughness, and stress rupture cracking.

3.1.2 Pre-Welding Preparations. Check ambient air temperature in work area. Welding should not be done in temperatures below 32 degrees F (0 degrees C). If ambient air temperature is below 32 degrees F, a heated structure is required to maintain temperature surrounding the weld repair area at 32 degrees F or higher. Support and secure damaged frame members and joints prior to welding according to the following procedure.

a. **Remove structural load from the joint(s).** Use jack stands or other cribbing to safely support both sides of the damaged area(s). Place other supports as required to prevent frame movement during inspection and welding preparation.

b. **Align members of damaged joint(s).** Ensure that broken or replacement pieces of the segment touch each other. Measure type, size and extent of each damaged weld that is to be repaired. NOTE: Repair welds should be of the same size and type as the original weld joint.

c. **Inspect cracks**. Determine the extent of weld or base metal crack(s) by use of dye penetrant inspection or any other equally positive means.

3.1.3 Preparation of Cracked Areas.

CAUTION

Do not use an oxyacetylene torch for gouging or metal removal due to the danger of overheating the base metal. High heat may result in a serious loss of T-1 material properties. Do not exceed maximum temperatures shown in Table 2.

a. Remove defective material and prepare joints. Remove old weld material or cracked base metal. Mechanically grind along the entire length of the crack. Extend the groove beyond each end of the crack, to a distance equal to twice the base metal thickness. Ensure that the depth of the groove is a minimum of 1/32 inch beyond the depth of the crack. Removal of material by chipping is acceptable.

WARNING

DO NOT INHALE CHEMICAL AGENT RESISTANT COATING (CARC) PAINT PARTICLES. CARC PAINT IS TOXIC. USE BREATHING RESPIRATOR WHILE REMOVING PAINT.

b. **Prepare surfaces**. Remove all paint, grease, scale, rust, water, etc., for a distance of 4 inches around the new weld area. Remove paint from the back and inside of all metal surfaces to be welded. Use mechanical or abrasive cleaning methods such as sandblasting, grinding, or degreased stainless steel wire brush.

3.1.4 Electrode Selection. Electrodes used for welding T-1 steel must meet proper tensile strength requirements and have a low hydrogen content to avoid hydrogen induced cracking. Electrode selection may also vary depending on the application and welding method. See Table 1 for a list of low hydrogen electrodes and processes which may be used to weld T-1 steel. The following is a guide for selecting electrodes.

a. Tensile Strength Selection. T-1 steels range in tensile strength from 50 to 150 ksi depending upon their grade and thickness. The following are general rules for their use:

- For structural members Select electrodes with a tensile strength equal to minimum tensile strength of 100 ksi.

- For non-structural members Select electrodes with a tensile strength less than that of the base metal, but within 70 to 80 ksi. Note: Typical non-structural members are fillet welds stressed in longitudinal shear, welds carrying secondary stresses, or welds joining a lower strength metal to T-1 steel.

- For dissimilar base metals Select electrodes with a tensile strength equivalent to that of the lowest strength base metal used.

Table 1. Electrodes Recommended for Welding ASTM A514 Steel

WELDING PROCESS	ELECTRODE RECOMMENDATION
Shielded Metal-Arc	EXXXI5-M per AWS A5.5
	EXXX16-M per AWS A5.5
	EXXX18-M per AWS A5.5
	EXXX28-M per AWS A5.5

Note: XXX represents the electrode tensile strength in ksi as required for the welding application.

b. Hydrogen Content. Use only low hydrogen content electrodes. T-1 steel is extremely susceptible to hydrogen-induced cracking in weld metal and in heat affected zones. Precautions must be followed to reduce the presence of hydrogen during welding including moisture contamination, a major source of hydrogen. The following general procedures apply to low hydrogen electrode selection and use.

- For shielded metal-arc welding use only low hydrogen electrodes which have electrode coating designations (last two digits of the AWS classification) of 15, 16, 18, or 28 (for example, E8015, E9016, E11018).

- To control moisture contamination, keep electrodes in hermetically sealed containers. Upon opening container, place electrodes into a holding oven at 250-300 degrees F. Follow manufacturer's instructions for electrodes which have been exposed to the atmosphere for longer periods. When welding, do not remove more than 1/2 hour's worth of electrodes at a time.

- In the event that electrodes are exposed to the atmosphere for longer than 1/2 hour, they must be placed in a ventilated baking oven set at 800 degrees F for 1 1/4 hours. In some cases, the electrode manufacturer may specify different exposure and baking time periods. Manufacturer guidelines shall be the governing document.

3.1.5 **Preheat and Welding Heat Input**. Excessive preheat and welding heat causes T-1 steel to become brittle resulting in a severe loss of strength. It is desirable to use a low total heat input and allow the base metal to cool quickly. This results in a small increase in hardness without the brittleness. Heat generated in the base metal weld area should be monitored by the use of temperature-indicating crayons or their equivalent to avoid excessive heat input and resultant brittleness and loss of properties.

Closely controlled preheat and inter pass temperatures must be maintained. When frame members are below the minimum temperature they shall be preheated for a distance equal to the thickness of the part being welded, but not less than 3 inches in all directions from the point of welding. (See Table 2). The following are general guidelines for preheating and total heat input.

a. Preheat and Interpass Temperatures. A weld bead, due to its high heat, shrinks faster than the surrounding base metal. This results in high stresses around the weld. By applying preheat, the weld bead will shrink more uniformly with the surrounding base metal thus minimizing the risk of cracks due to shrinkage. The thicker the base metal or the more restrained a joint, the higher the preheat temperature must be. The minimum/maximum preheat and Interpass temperatures listed in Table 2 have been established for all materials conforming to ASTM A514, which includes all T-1 steel types.

Table 2. Suggested Preheat and Interpass Temperatures for ASTM A514 Steels

THICKNESS RANGE (IN)	MINIMUM PREHEAT AND INTERPASS TEMP (°F)	MAXIMUM PREHEAT AND INTERPASS TEMP (°F)
Up to 0.75	50	400
0.76 to 15	125	400
1.51 to 2.5	175	450
Over 2.5	225	450

b. Welding Heat Input. The total welding heat input is determined by three factors: welding voltage, amperage, and speed. To determine the total heat input for a given weld, use the following formula:

Heat Input (kJ/in) = Amperes x Volts x 60/ 1000 x Speed (in per minute)

When welding T-1 steels, the total welding heat input must be equal to or less than the values given in Tables 3 and 4. Given the preheat temperature and base metal thickness, the above heat input formula can be used to ensure than the heat input remains within the limits given in the table. The heat input can be adjusted by decreasing welding amperage and voltage or by increasing the welding speed. Note: The total heat input referenced in Tables 3 and 4 applies to individual weld passes and is not considered cumulative.

Table 3. Welding Heat Input (Kj/m) T-1 and T-1 Type C Steels

PREHEAT TEMP (OF)	SECTION THICKNESS (IN)						
	0.19	0.25	0.5	0.75	1.0	1.25	1.5
50	28	37	72	125	*	*	*
70	27	36	70	121	*	*	*
100	25	34	67	116	208	*	*
150	23	32	62	107	188	*	*
200	21	29	56	99	173	*	*
300	17	24	47	82	126	175	*
400	13	19	40	65	93	127	165

Table 4. Maximum Welding Heat Input (Kj/in) for T-1 Steel Types B and C

PREHEAT TEMP (°F)	SECTION THICKNESS (IN)						
	0.19	0.25	0.5	0.75	1.0	1.25	1.5
50	19	25	48	92	*	*	*
70	18	24	47	89	137	*	*
100	17	23	45	84	131	*	*
150	15	21	42	77	120	*	*
200	14	19	38	70	110	154	*
300	12	16	32	56	86	120	*
400	9	12	26	42	66	94	124

3.1.6 **Welding Techniques**. The following welding techniques are designed to minimize heat input and to reduce areas of high stress concentration.

a. Stringer Bead vs. Weave Bead Technique. It is desirable to minimize the heat input while welding T-1 steels. With the stringer bead method, weld beads are deposited in a straight line; with the weave bead method, weld beads are deposited in a zigzag formation. (See Figure 1) The use of stringer beads reduces the amount of heat input, because the forward weld travel speed is faster. Therefore, the stringer bead technique should be used instead of the weave bead technique. The exception to the stringer bead requirement occurs when welding in the vertical position. In this case, a partial-weave technique may be used to facilitate welding. However, the total weave shall not be greater than twice the electrode diameter.

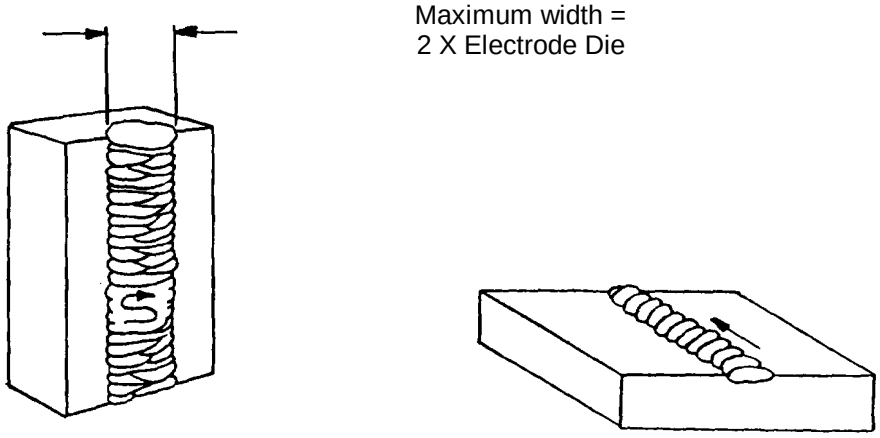


Figure 1. Straight and Partial Weave Welding Methods.

b. Back Step Technique. When using low-hydrogen electrodes, the back-step method must be used for each string of weld bead. The purpose of the back-step method is to reduce weld porosity at the arc initiation point, thus resulting in a stronger weld. The following is the back-step method.

(1) Strike the arc one in inward from the intended starting point of the weld string.
(2) Weld outward to the intended starting point.
(3) Reverse direction and weld back over the one in of newly deposited weld.
(4) Continue welding along the crack.

c. Multiple Pass Welding. Use small, multiple weld beads, as opposed to large, single or double weld beads. The small, multiple weld beads will exhibit better notch toughness due to the tempering effect of additional weld passes.

Also, smaller weld beads require less heat input than larger ones. Use a minimum of three weld passes per crack when welding T- Steels. All flux, scale, and oxide must be removed from each weld bead prior to depositing an overlapping bead. Mechanical means such as a hammer or wire brush are recommended. All weld passes, except for the first and final, must be peened to reduce undesirable stresses caused during shrinkage of the weld material. The peening process is most effective while the weld and base metal are still hot.

d. **Soft Wire Spacers**. To reduce the high stresses caused by weld shrinkage, soft wire spacers can be used for fillet welds. The spacers can be any low carbon steel wire. Because the wire material is more ductile than the high strength weld bead, wire acts like a cushion or buffer between the welded members, thus reducing weld stresses. (See Figure 2.) Soft wire spacers are normally used for joint thickness of 2 inches or greater.

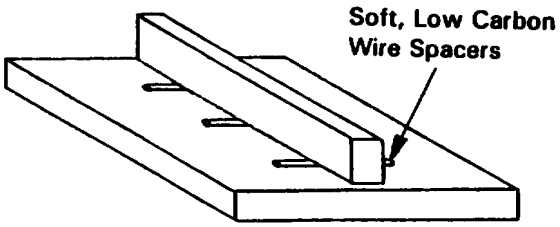


Figure 2. Wire Spacers

e. Surface Weld Fillet Welds. The incorporation of surface or butter welds at the toe section of fillet welds will provide additional relief from stresses due to weld shrinkage. Prior to depositing a fillet weld, determine the approximate location of the weld toe. Deposit a minimum of 2 to 3 surface weld beads with a low-strength weld metal. Complete the mufti-pass fillet weld using the roper, full strength welding electrode. Cover only half of the surface weld beads with full strength material as shown in Figure 3. The surface weld will provide additional ductility at the highly stressed toe section of the fillet weld and will reduce the risk if cracking due to shrinkage. Surface bead fillet welds are normally used for joint thickness of 2 inches or greater.

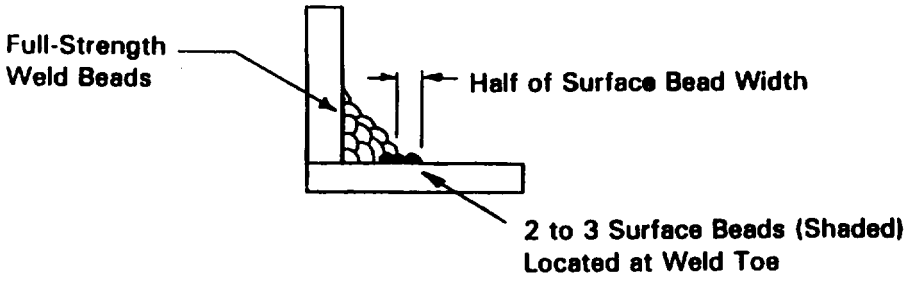


Figure 3. Surface Beads in Fillet Welds

3.1.7 **Reinforcement Plates**. When using reinforcement plates in the repair of damaged structures, heed the following guidelines.

a. Crack Preparation and Weld. Fill weld the crack following the preheat, heat input, and welding technique guidelines from previous sections. Grind the new weld joint so that the reinforcing plate will fit flush on top of the welded member segments.

b. Material and Thickness. Fabricate the reinforcement plate of the same material as the damaged frame member. In most cases, if multiple frame members of differing material are being joined, the reinforcement plate material should be that of the lowest strength member. The reinforcement plates shall have a thickness range of 1 to 1 1/4 times that of the component to be reinforced.

c. Damaged Reinforcement Plates. Remove and replace cracked or broken reinforcement plates with new plates of the same design and material. Do not weld repair cracks in the reinforcement plate.

d. Reinforcement Plate Installation When installing a reinforcement plate, do not completely weld the plate all around. Use intermittent (skip) welds to allow for proper joint cooling, to minimize concentrations of internal stresses resulting from welding, and to avoid frame warping.

3.1.8 **Weld Inspection**. All T-1 steel welds must be carefully inspected to ensure good weld bead characteristics. In general, inspection should follow the guidelines listed below. Carefully inspect all joints visually. The high strength of the base metal and weld electrodes result in higher internal stresses than with welds in low carbon steel. Ensure that all T-1 steel welds exhibit the following characteristics:

- no visible weld cracks in the base metal
- all craters filled, except for ends of intermittent fillet welds outside of the effective length
- replacement weld joints of the same type and size as the original weld
- base metal repair welds achieve full thickness of the base metal
- single continuous fillet welds may not underrun nominal specified fillet weld size by more than 1/16 inch without correction, and the undersized portion may not exceed 10% of the weld
- no underrun permitted at the ends of web-to-flange welds on girders, for a length equal to twice the width of the flange.
- for primary members, undercut shall not exceed 0.01 inch deep where weld is transverse to tension loading stress under any design load condition
- all other undercuts shall not exceed 1/32 inch -deep
- minimum changes in cross section
- minimum offsets in member alignment (a 3 to 1 taper in weld width will minimize the negative effects of alignment offsets)
- smooth, concave contour along the face of the weld
- good weld penetration

3.1.9 Treat/Paint Repaired Joint.

Treat and paint welded joints, new material, and reinforcement plate areas according to the requirements of TACOM Drawing Nol 19207-12344846-400, *Treatment and Paint Spec for Tactical Vehicles and Components*. Call DSN 786-8278 if you need to obtain a copy of this drawing.

SECTION III. M747 TRAILER RAMP

4.1 WELDING PROCEDURES

4.1.1 Introduction to 6061 T6 aluminum. The chief alloying element of 6061 aluminum is magnesium-silicon. It is a heat-treatable wrought aluminum alloy. The T6 suffix code indicates that the alloy is solution heat treated, then artificially aged. The 6061 T6 alloy has a yield strength of 40,000 psi, ultimate strength of 45,000 psi, and Brinell hardness of 95. Its mechanical properties increase as a result of heat treating. Some precautions are required when welding to maintain these properties. In particular, care must be taken to not overheat the alloy since it has low melting temperature. Weld cracking in aluminum is often due to the low strength and ductility of the weld metal used or of the heat-affected zone as a result of elevated temperatures.

4.1.2 Pre-Welding Preparations. Although 6061 aluminum is highly weldable, proper welding procedure and cautions must be followed.

a. Check work area conditions.

(1) **Check ambient air temperature in work area**. Welding should not be done in temperatures below 50 degrees F. If ambient air temperature is below 50 degrees F, a shelter or heated structure should be provided to maintain the air temperature at 50 degrees F or higher. Welding shall not be done when the weld surfaces are wet or exposed to rain, sleet, frost or excessive wind or when welders, welding operators or tack welders are exposed to inclement conditions.

(2) **Check draft conditions**. Gas tungsten arc and gas metal arc welding shall not be done where draft conditions exist and wind velocity exceeds 5 miles per hour. If such conditions exist, a shelter or windbreak of appropriate material and shape must be erected to reduce the velocity of the wind in the work area.

b. Secure damaged ramp frame members and joints prior to assessing cracks and welding.

(1) **Remove structural load from the joint(s).** Use jack stands or other cribbing to safely support both sides of the damaged area(s). Place other supports as required to prevent ramp frame movement during inspection and welding preparation.

(2) **Align members of damaged join(s).** Ensure that broken or replacement piece s of the segment touch each other.

c. Measure type, size and extent of each damaged weld. NOTE: Repair welds should be of the same size and type as the original weld joint

d. Inspect joints and base metal. The extent of each crack shall be ascertained by use of dye penetrant, x-ray examination or other non-destructive means.

4.1.3 Preparation of Cracked Areas.

a. **Remove defective weld metal or cracked base metal by mechanical means**. Remove material beyond the ends of the crack for a distance equal

to twice the base metal thickness. The depth of the groove shall be a minimum of 1/32 inch beyond the depth of the crack. Grinding of aluminum, except for final weld contouring and finishing operation, is not recommended. When grinding is unavoidable, use non-loading type abrasives specifically for aluminum. As a last resort, air carbon arc cutting may be used for gouging if available; however, the arc should not be used to remove all the metal in the joint. Leave a minimum of 1/4 inch of material and remove it with a grinder. Note: carbon residue must be removed. A degreased stainless steel wire brush may be used to clean cracks and joints.

b. **Avoid overheating the base metal when removing defective material**. High heat may result in a serious loss of the material properties.

c. **Avoid undercutting, nicking or removing neighboring weld material or undamaged base metal**. Metal must later be added to the surface to compensate for any deficiency in size.

d. **Prepare surfaces to be welded**. Prepare edges and joint surfaces to be welded by shearing, swing plasma arc cutting, chipping, planing, milling, or routing. Surfaces to be welded shall be smooth, uniform, and free of fins, tears and cracks. A degreased stainless steel wire brush may be used to clean cracks and joints.

WARNING

Do not inhale Chemical Agent Resistant Coating (CARC) paint particles. CARC paint is toxic. Use breathing respirator while removing paint.

CAUTION

If material is not welded promptly, oxides which readily form on all aluminum surfaces, must be removed before welding.

e. Clean surfaces. Cleanliness is critical to ensure good weld quality. Remove all paint, grease, scale, rust, water, etc., for a distance of 4 inches around the new weld area. Remove paint from the back and inside of all metal surfaces to be welded. Use mechanical or abrasive cleaning methods such as sandblasting, grinding, or wire brush. When wire brushing is used, only new, degreased stainless steel wire is acceptable. Steel/iron or brass/bronze must not be used because they create galvanic corrosion problems. Brushes previously used to clean or prepare steel surfaces shall not be used.

4.1.4 Electrodes/Filler Metal Selection. The 6061 alloy is very susceptible to cracking. Use a filler metal of higher alloy content than the parent metal to reduce weld cracking. Do not use 6061 filler metal. Filler metal with a melting temperature below that of 6061 will reduce the shrinkage stress. The recommended filler metal is either Type 4043 (electrode type ER 4043) or 5356. Use 5356 for joints requiring a combination of strength and ductility, typically high-stress joints. Use 4043 for low-stress joints and those joints requiring better corrosion resistance than 5356 or which cannot accommodate any cracking.

4.1.5 Welding Process Selection. The welding process shall be either gas metal arc (GMAW) or gas tungsten arc (GTAW).

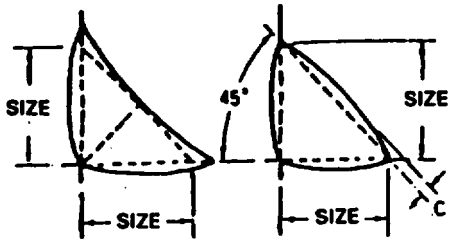
4.1.6 Shielding Gas Selection. Argon, helium, or mixtures of argon and helium used for shielding shall be a welding grade having a dew point of -63 degrees F or lower.

4.1.7 Preheat and Welding Heat Input. Excessive preheat and welding heat causes 6061 T6 aluminum to lose its heat treated properties. Preheating is normally not required, except for thick sections. However, when the temperature of the weld area and surrounding base metal is below the allowed minimum temperature, the base metal shall be preheated so that the parts on which the weld metal is being deposited are at or above the minimum temperature for a distance equal to the thickness of the parts being welded, but not less than 3 inches both laterally and in advance of the welding. A controlled and moderate preheat can reduce the total required heat input, enhance weld penetration, and avoid thermal stresses. Preheat temperatures for 6061 T6 should not exceed 300 degrees F. This heating is to be done before welding is started and will also serve to drive moisture from the region of the weld. To prevent the metal from distorting, use step welds and/or mufti-directional welds. Temperature indicating crayons or other pyrometric checks should be used to monitor temperature.

4.1.8 Weld Profiles and Joint Requirements.

a. Aluminum joint designs are similar to steel joints. The faces of fillet welds may be slightly convex, flat or slightly concave as shown in figure 4. With the exception of

outside corner joints, the convexity ("C") of a weld or individual surface bead shall not exceed the values listed in Figure 4, and shall have a gradual transition to the plane of the base metal surface.



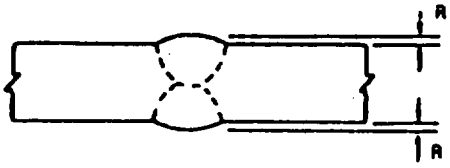
NOTE: Convexity, C, of a welded or individual surface bead shall not exceed 0.057 times the actual face width of the weld or individual bead, respectively, plus 0.06in .

Figure 4. Desirable Fillet Weld Profiles

b. Surfaces of butt joints required to be flush, shall be finished so as not to reduce the thickness of either of the base metals or weld metal by more than 1/32 inch or 5% of thickness, whichever is smaller, or leave reinforcement that exceeds 1/32 inch. See Figure 5 for reinforcement values.

c. All reinforcement shall blend smoothly into the plate surfaces with the transition areas free from edge weld undercut. Where the weld forms part of a faying or contact surface, all reinforcement shall be removed. Chipping may be used, provided it is followed by grinding or other smoothing operations. Welds shall be free from overlap.

d. Careful joint fit-up is essential for a good quality weld. Rigid fixtures can be used to minimize distortion. Backing bars may be used with butt welds. Tack welding may be used for ease in reassembling joints; however, tack welds tend to be low quality and therefore should be removed as the rampis reassembled.



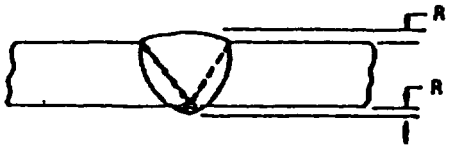
DOUBLE GROOVE WELD IN BUTT JOINT

MAXIMUM REINFORCEMENT FOR A GIVEN PLATE THICKNESS—JOINT WELDED FROM BOTH SIDES

THICKNESS, t		MAXIMUM REINFORCEMENT	
in	mm	in	mm
t ≤ 3/8	t ≤ 9.5	3/32	2.4
3/8 < t ≤ 3/4	9.5 < t ≤ 19	1/8	3
t > 3/4	t > 19	3/16	5

FIGURE 5. DESIRABLE GROOVE WELD

MAXIMUM REINFORCEMENT FOR A GIVEN PLATE THICKNESS-JOINT WELDED FROM BOTH



THICKNESS, t		MAXIMUM REINFORCEMENT	
in	mm	in	mm
t ≤ 1/4	t ≤ 6 4	3/32	2 4
1/4 < t ≤ 1/2	6 4 < t ≤ 12 7	1/8	3
1/2 < t ≤ 1	12 7 < t ≤ 25 4	5/32	4
t > 1	t > 25 4	3/16	5

GROOVE WELD IN BUTT JOINT WELDED FROM ONE SIDE

Figure 5. Desirable Groove Weld - Cont.

e. Undercuts are permissible if they are in compliance with Table 5, as follows.

f. On multi-pass welds the beads shall be wire-brushed with a degreased stainless steel brush. Brushes that have been used to clean steel may not be re-used.

Table 5. Permissible Undercut Values

THICKNESS	PRIMARY STRESS DIRECTION	MAXIMUM UNDERCUT
1/8 to 1 in	Transverse	0.01 in
Over 1 in	Transverse	0.03 in
All	Parallel or none	0.03 in

4.1.9 Welding Techniques - Gas Tungsten Arc Welding (GTAW)

The following restrictions on the GTAW procedures must be observed at all times.

a. The maximum size of fillet weld made in one pass shall be no more than 1/4 inch for all positions.

b. The thickness of weld layers shall not exceed 1/4 inch. When the root opening of a groove weld exceeds 3/8 inch, a multiple pass, split layer technique shall be used. The split layer technique shall be used also when making all multiple pass welds when the width of the layer exceeds 3/8 inch.

c. The welding current, voltage, gas flow, filler metal diameter and travel speed shall be such that each pass will have complete fusion with adjacent weld metal and base metal. There shall be no overlap, excessive porosity or undercutting in excess of Table 5.

d. The welder shall employ the forehand technique.

4.1.10 Welding Techniques - Gas Metal Arc Welding (GMAW) with Single Electrode .
The following restrictions on GMAW procedures must be observed at all times.

a. The maximum size of a stringer bead fillet weld make in one pass shall be 1/2 inch for the flat and vertical positions and 3/8 inch for horizontal and overhead positions.

b. The thickness of weld layers, except root and surface layers shall not exceed ¼ inch. When the root opening of a groove weld exceeds 3/8 inch, a multiple pass split layer technique shall be used. The split layer technique shall also be used in making all multiple pass welds when the width of the layer exceeds 1/2 inch.

c. The welding current, voltage, gas flow and travel speed shall be such that the arc is in the spray transfer made and that each pass will have complete fusion with adjacent weld metal and base metal. There shall be no overlap or excessive porosity or undercutting in excess of the values provided in Table 5.

d. Runoff tabs may be used to break the arc, thus avoiding formation of crater cracks.

e. The progression of all passes of vertical position welding shall be upwards.

f. Welder shall employ the forehand technique. A backhand technique shall be permitted for root pass disposition when the welder is qualified for that technique

g. Complete joint penetration groove welds make without the use of backing shall have the root of the initial pass back gouged, chipped or otherwise removed to sound metal, and all trace of root discontinuity shall be eliminated before welding is started from the second side.

4.1.11 Weld Inspection - Visual. All welds shall be visually inspected. All welds must exhibit the following characteristics:

- no visible cracks in surface of weld or base metal
- thorough fusion exists between adjacent layers of weld metal and base metal
- all craters filled

- weld profiles are in accordance with paragraph 4.1.8 -
- undercut does not exceed the values provided in Table 5
- replacement weld joints of the same type and size as the original weld
- base metal repair welds achieve full thickness of the base metal
- single continuous fillet welds may not underrun nominal specified fillet weld size by more than 1/16 inch without correction, and the undersized portion may not exceed 10% of the weld
- no undersized fillet weld permitted at the ends of web-to-flange welds on structural members, for a length equal to twice the width of the flange
- no visible metallic inclusions in weld

4.1.12 **Treat/Paint Repaired Joint**. Treat and paint welded joints, new material, and reinforced areas according to the requirements of TACOM Drawing No. 19207-12344846-400, Treatment and Paint Spec for Tactical Vehicles and Components and Drawing No. CPR101077, For Ramp Assembly.

REFERENCES

TECHNICAL MANUALS.

Operator's, Organizational, Direct Support, and General Support Maintenance: Semitrailer, Lowbed,: Heavy Equipment Transporter, 60 Ton, M747.....TM9-2330-294-14

Operator's Manual Welding Theory and Application TM9-237

MILITARY STANDARDS

Arc Welding Procedures for Construction Steels ..... MIL-STD-1261C(MR)

Welding, Gas Metal Arc and Gas Tungsten-Arc, Aluminum Alloys, Readily Weldable for Structures, Excluding Armor.....MIL-STD-372(MR)

OTHER PUBLICATIONS

Aluminum Association, Inc., The. 1990. *Aluminum Standard and Data*. Washington, DC: Aluminum Association, Inc. The

American Society for Testing and Materials. 1992. 1992 *Annual Book of AStM Standards Iron and Steel Products*. Volume 01.04. Philadelphia: American Society of Testing and Materials

American Society for Metals. 1979. *Metals Handbook. Volume 2. Ninth Edition*. Metals Park, OH: American Society for Metals.

American Welding Society. 1982. *Welding Handbook*. Volume 4. Seventh Edition. Miami:

American Welding Society. United States Steel International, Inc. 1981. *How to Weld T-1 Construction Alloy Steels*. Pittsburgh: United States Steel International, Inc.

United States Steel International, Inc. 1985. *Properties Card T-1 Constructional Alloy Steel*. Pittsburgh: United States Steel International Inc.

APPENDIX F - SAE J875

TRAILER AXLE ALIGNMENT - SAE 1875 SAE RECOMMENDED PRACTICE

Purpose-The purpose of trailer axle alignment is to establish a perpendicular relationship between the kingpin centerpoint and the axle centerline at its midpoint.

Procedure-Trailer axle alignment shall be effected with the trailer suspension unit in a relatively free position to relieve stress in rubber bushings or other parts of the suspension system that may be under stress. The trailer axle alignment gage shall be designed so that removal of parts from the trailer is not required and that an accurate, yet simple alignment can effected.

The alignment gage shall have platforms on which the trailer wheels are driven that have the facility to center the wheels. These wheel platforms should be constructed so they are free to pivot and move in a fore and aft direction. Such movement will permit any stress in the suspension to be relieved and allows the true centerline of the axle to be established. The platforms shall also be capable of supporting a loaded trailer.

Means should be provided to indicate the relative position of common points on the wheel platforms at each end of an axle. This will represent a reference line that is parallel to the axle in the free position.

The midpoint of the axle must be located and projected to the transverse reference line that is parallel to the axle.

A vertical line should be established from the kingpin by suspending a plumb bob or with a level rod (pogo stick).

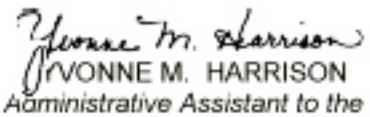
To align an axle correctly, the perpendicular bisector of the axle or reference line, in a horizontal plane, must intersect the perpendicular line from the kingpin.

Projection of the perpendicular bisector of the axle to the kingpin vertical may be accomplished with a beam of light or optical sighting.

By Order of the Secretary of the Army:

DENNIS J. REIMER
General United States Army
Chief of Staff

Official:



YVONNE M. HARRISON
Administrative Assistant to the
Secretary of the Army

DISTRIBUTION;
To be distributed in accordance with DA FORM 12-34-e, block 4570, requirements for TB 9-2510-242-40.

*U.S. GOVERNMENT PRINTING OFFICE 1995746-914/20105

TEAR ALONG PERFORATED LINE

RECOMMENDED CHANGES TO EQUIPMENT TECHNICAL PUBLICATIONS

SOMETHING WRONG WITH THIS PUBLICATION?

FROM: (PRINT YOUR UNIT'S COMPLETE ADDRESS)

DATE SENT

PUBLICATION NUMBER	PUBLICATION DATE	PUBLICATION TITLE

BE EXACT. . .PIN-POINT WHERE IT IS

PAGE NO.	PARA-GRAPH	FIGURE NO	TABLE NO.

IN THIS SPACE TELL WHAT IS WRONG AND WHAT SHOULD BE DONE ABOUT IT:

PRINTED NAME, GRADE OR TITLE, AND TELEPHONE NUMBER

SIGN HERE:

DA FORM 1 JUL 79 2028-2

PREVIOUS EDITIONS ARE OBSOLETE.

P.S.—IF YOUR OUTFIT WANTS TO KNOW ABOUT YOUR RECOMMENDATION MAKE A CARBON COPY OF THIS AND GIVE IT TO YOUR HEADQUARTERS.

PIN: 074261-000